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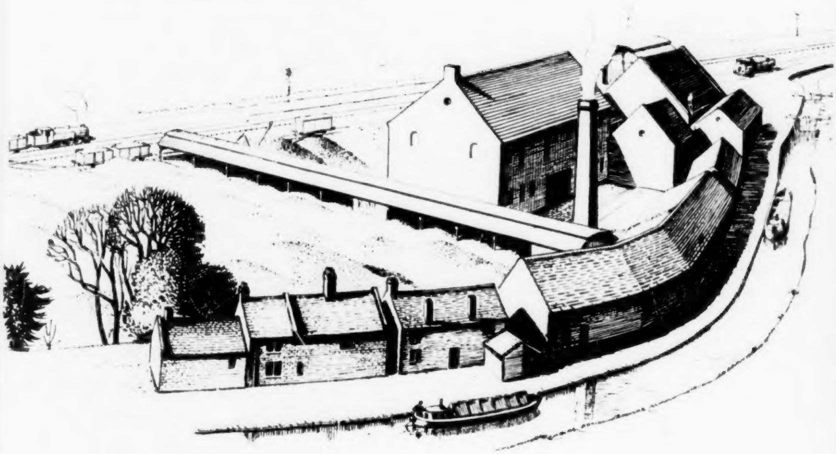

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ONDON

CERAMICS

MARCH, 1951

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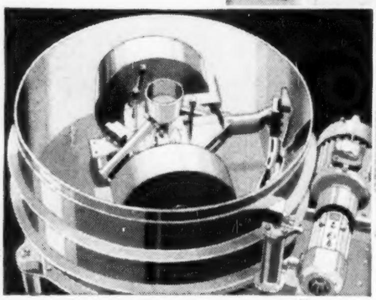

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CERAMICS

VOL. III MARCH, 1951 NO. 25

NORTH STAFFORDSHIRE UNIVERSITY COLLEGE OPENING

ON the 17th April, 1951, Her Majesty The Queen will officially open the new University College, which undoubtedly offers an added scope to the educational facilities of North Staffordshire.

However, it is to be hoped that the appearance in the potteries of another institution for higher education will not lead to a diminishment of interest and support for the North Staffordshire Technical College itself. The latter has through the years contributed much to the industry of the area. It has always been blessed with heads of the ceramic department who were in intimate touch with the industry upon which the whole of the potteries survives.

Eminent thinkers and practical industrialists have in recent years expressed grave doubts as to the adequacy of the prevailing approach to the training of future technologists, represented by our traditional university outlook.

They have stressed that the pure science university faculties train their students for fundamental research, and they are left to learn their jobs as technologists afterwards.

It will be wrong indeed if the University and the Technical College compete for students in a manner such that the better ones are all creamed into the University College. Yet, the latter can offer a mystical "gong" like a B.Sc. degree!

The new University College science faculties and the technological departments of the Technical College could between them surely offer the first British B.Sc. Degree in Ceramic Technology? Conjointly they have much to offer, but it will be a tragedy in the extreme if they pursue their ways independently.

The future of these two institutions is of vital concern to the industrialists of North Staffordshire. If industry takes action now to mould the future of both educational institutions they will ensure that they get an out-flow of trained technologists—not scientists—who have a balanced understanding of the theoretical and practical notions of their craft!

COMMENT

by **ARGUS**

MR. GAITSKELL as Chancellor of the Exchequer mentioned pottery as one industry which will have to increase its exports to make up for losses elsewhere, and which is to have a new target set for it.

How much more is possible with a shortage of female decorators and increased labour competition from the near-by Royal Ordnance factories is doubtful. As an incentive to increased production, since January of this year industrial electricity costs in North Staffordshire have gone up by about a quarter, coke and coal have both increased in price and simultaneously been curtailed in availability.

Shortage of Bone

The Director of the British Pottery Manufacturers' Federation has been in touch with the Board of Trade regarding the shortage of bone from the Argentine which is likely to affect the British china manufacturing industry. It represents round about 10 per cent. of the total production costs of the best Staffordshire china and of course it is the bone which imparts the distinctive whiteness and translucency to Staffordshire china, whilst the tensile strength endowed has taken the product beyond competition elsewhere in the world.

The President of the Board of Trade for one reason or another has had to cancel his visits to the North Staffordshire area on more than one occasion. No doubt there will be a number of leading questions to be put before him. Those mentioned above are but two. Competition from Japan in America, about which little or nothing tangible seems to be done because the new "Mikado" either will not or cannot take action is another. The President of the Board of Trade is wanted in North Staffordshire by the Chamber of Commerce but some positive action from him is needed on the pertinent points which have been raised by the industry over and over again.

A new factory to produce 450 tons of finished porcelain ware a year to expand to 800 tons in about 2 years is envisaged by a Government factory in Ceylon and tenders will go out to manufacturers who can quote for the entire project. It represents but the shape of things to come.

Development Council

Questions have been put to the President of the Board of Trade regarding the proposal to set up a Development Council in the Pottery industry, and Mr. Wilson said recently in the House that details are now being worked out by his department. He intimated that he knows not how soon the Council will be implemented. Reference was made in the House to both sides of the industry being carried forward in this matter. There is a third side of the industry whose work vitally affects both the manufacturers and the workers, namely the Pottery Managers. Is it not about time that commonsense prevailed and that these managers, who will still be there doing the job irrespective of what happens in the end, were called in to express a vital opinion?

Transport House and Whitehall are both in London. Both tend to be bureaucratic in outlook and organisation. Both think that it is

possible to direct an industry of which they know nothing, by remote control. Here is an opportunity for the managers to guarantee that they get an even break, which in the end will ensure that all the "doers" are given the favoured treatment they deserve. If anyone has to give way, it must be the "planners," for no plan has ever earned a penny-piece until somebody implemented it.

Surely the Pottery Worker's Society and the Manufacturers' Federation will find the balanced viewpoint of the managers, who maybe work *for* the latter, but *with* the former, to their mutual advantage.

But Mr. Wilson ought to make an early visit to North Staffordshire if only to hear himself likened to the man in the Prayer Book who "has done those things he ought not to have done, and left undone those things he ought to have done."*

Looking Ahead

There is a tremendous future awaiting the ceramic industry, if it will abandon its insular attitude of pottery, clay, refractories and so on. Technical development—by this I do not mean research in the accepted sense of the word—can maintain the standard of British pottery and reduce its price. Likewise, on the heavy clay side, there is still a mass of antiquated Victorian equipment doing a job much more expensively than it could be done even with extensive use of new equipment which has already been developed.

Looking ahead, what are the basic problems which face most new industrial techniques? We talk in terms of the gas turbine, of atomic energy. Nevertheless, in metallurgy and in the fields mentioned above progress is governed largely by the physical properties of materials already known, in so far as they will withstand corrosion and high temperatures. It has already been established that gas turbine performance is improved by operating temperatures above 1,600° C. The materials or coatings used must, however, resist oxidation, they must be easy to apply and they must withstand both corrosion and erosion influences. Metallurgical developments are essentially tied up with the use of refractories. The electrical industry is in need of better insulators.

Doubtlessly, just as metallurgical research and development made the gas turbine a possibility, so ceramic refractory materials will take it one stage further and simultaneously affect progress in the development of the atomic energy projects.

D.S.I.R.

This is the sort of research which is worth money and time, but will not be implemented by the pure scientists. It will be carried out by men with practical knowledge of day-to-day problems. At present there are a spate of academic scientists, and a gross deficiency of trained technologists. And the Department of Scientific and Industrial Research has laid the emphasis upon science and more or less overlooked industry except for finding the finance.

Witness another of its ventures. There is an Intelligence Department of D.S.I.R. located in Whitehall, which publishes a little broadsheet called *Unanswered Questions*. Apparently they are questions which the resources of the organisation cannot find answers to by their normal process of searching. Most of the unanswered questions are related to fundamental research. In a perfect world to have a D.S.I.R. department where one could apply for an answer to any question would be an ideal state of affairs. In the end it would mean that the State once more takes over the job from the individual, making him depend less and less upon his own initiative.

* As we go to press Mr. Wilson has at long last visited Stoke. We shall see, what we shall see.

But this in itself would have a snowball effect and would grow to prodigious limits; more bodies, more expense adding to the State patronage of the individual but at an expense which sooner or later the individual can no longer carry. State patronage is an expensive form of patronage, because the tax-payer is patronising himself at prodigious expense through a third party who is doing very well out of the deal.

Exploitation of Ideas

I heard a director of a research board say the other day that the scientists and fundamental research worker should not bother about the exploitation of his ideas and researches! It was up to the other folks to make use of them if they wanted to! Do these research folk forget that the block grants which they spend in the research associations come from the people whom they are asking to exploit their ideas? Might it not be that those who "should" exploit the ideas are so dilatory in using the results of scientific research in the research associations, but that the research associations themselves were failing to produce realistic research programmes? Is it the customer who is still wrong?

"In Town Tonight"

I am indebted to the *Design Calendar* issued monthly by the Council of Industrial Design for keeping me informed of what is "in town tonight."

For example, one could go along to that august Victorian building in John Adam Street in which is housed the Royal Society of Arts and you can hear a lecture under the title "The Design of Amusement Machines." Always that building inspired me with fear and awe and yet I cannot help myself thinking of the folks who would be interested in this subject. Surely it would be the "boys" who frequent those steamy annexes just off Piccadilly and Tottenham Court Road run by the well-known gentlemen whose office attire is a cricket shirt or padded shoulders. How I wish I could have managed to see them against the background of the learned precincts of the Royal Society of Arts.

Alternatively, there is an exhibition of "Playing Cards and Parlour Games" at the Victoria and Albert Museum. The trouble of a mis-spent youth is that parlour games are always considered apart from playing cards. The former is essentially co-educational and the latter definitely an all-masculine affair.

Else, of course, you can go to the "More Power Exhibition" at British Electricity House. Once they used to try and sell electricity, but now to use it has become a national crime—shades of Michael Faraday—but what can you expect from the invention of a man who began by washing bottles for Sir Humphrey Davey, particularly when it is taken over by the electroplanners?

Architecture and British Railways

Or perhaps, you would like to go along to an exhibition entitled "The Architecture of Transport" sponsored by the Royal Institute of British Architects. I am informed that it has been boycotted by British Railways! Their architects tell me they refuse categorically to depart from the early Victorian and Edwardian style of buffets, waiting-rooms and other travelling amenities. As a counter to this exhibition, they are running their own show with a centre display of a facsimile model of that well-known modern railway junction at Crewe.

Then there is an exhibition entitled "Furniture Today" which is sponsored by the Council of Industrial Design itself. Here the young couple were shown how with £500 in cash they can set up home with Scandinavian type furniture which is

(*continued on page* 40.)

Mechanical Aids to Production in the Ceramic Industries

A REVIEW

(SPECIALLY CONTRIBUTED)

IN recent years the mechanical aids to production have increased at such a rate that it seems profitable at this stage to review them, and to speculate on future trends in the ceramic industries.

In this review we shall study not only pottery and allied products such as tiles and sanitary earthenware, but also that group of industries commonly called the heavy clay-wares group, etc.

It will be convenient to study these under the following headings. Mechanical aids in:

(1) Getting the raw materials, e.g. clays;

(2) Forming the ware and moving it about the shops;

(3) Drying and firing it;

(4) Decorating the ware, if this is done.

Possibly the most spectacular advances have been made under section (2), but it should never be forgotten that it is useless to install machines to produce at a high rate unless the facilities are available for handling, drying and firing at comparable speeds. Equally, it is no use producing at rates greater than the market can absorb—a fact which has tended to be overlooked in some countries, and which has since caused some modification in ideas on mechanical production of pottery in particular.

Getting the Clay

The enormous amount of excavation, etc. required during the war years for building airfields, factories, magazines, etc., has resulted in amazing progress in all types of equipment now available for digging clay and other raw materials. This is indeed fortunate since at present clay is needed in great and increasing amounts, and the labour force available for this uncongenial job tends to diminish. Bulldozers, planes, steam shovels and draglines are now available in variety for tackling large and small jobs of this nature.

An Example

In one brick works needing 42,000 tons of clay a week the whole of this is obtained with the following equipment—a dragline ripping off the overburden and dumping it into the worked out portions of the pit with a gantry conveyor; a large electrically operated power shovel digging 10 tons of clay at a single bite into a 60 ft. deep clay seam; a hopper and sorting table, and a steam locomotive to haul away the tubs of clay.

Labour Required

The whole is operated with 5-6 men. Admittedly conditions at the clay face are not often as favourable as this, but in more difficult conditions, mechanical spades operated by compressed air and diesel driven shovels and dumping cars can make surprising differences to clay output. Belt conveyors are being increasingly used to move clay from the pit to the works. These developments have been reviewed in a recent article entitled "Modern Trends in Manufacturing Bricks"

(CERAMICS, July, 1950, pp. 228-237) and it is not necessary to go into further detail here.

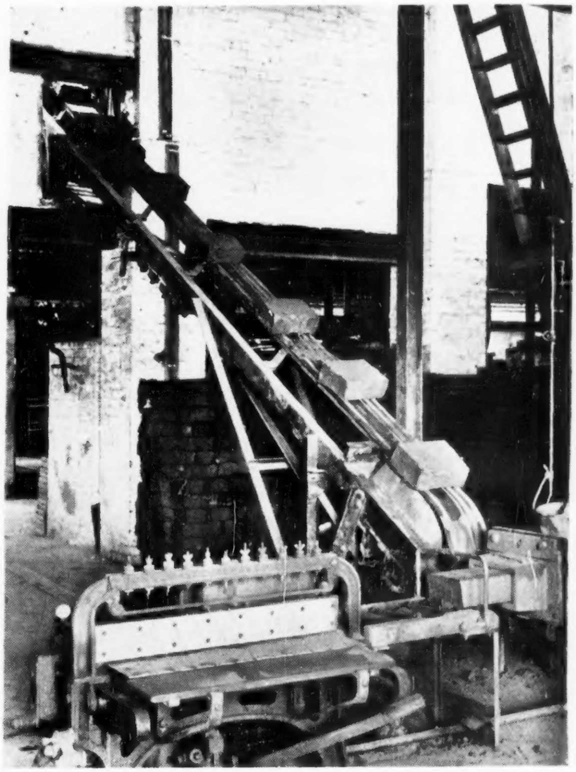
Dewatering and Drying of Clays

China clays are now beginning to be dewatered by filter presses and centrifuges instead of the old drying stoves, while a machine which pulverises and dries clay to predetermined moisture contents is now available, and is being used for preparing clay for dust-pressed floor quarries and further applications are envisaged (cf. CERAMICS, October, 1950, pp. 397-404). The same machine is being used for preparing ground, dried ball clay. This makes possible a system of mixing pottery and other bodies by a dry method, which has been almost universally adopted in the U.S.A. but which has not as yet found much application over here.

So much then for the job of winning the clay.

Forming the Clay

It is in forming the clay into the ware that in recent years considerable attention has been focussed on mechanical aids. For many years brick presses had been used to turn out bricks by the million so that hand-made bricks were only made for special purposes. This had been accepted, but for long it was felt that this could not be done with pottery. Just as surely, however, as the jolley replaced the throwers in industry, so now the fully and semi-automatic machines are increasing



Modern trends in manufacturing bricks. Showing slabs received from pug mill cutting table, loaded by hand on to a conveyor, which conveys them up a 30° incline and delivers over terminal to floor above

(Courtesy: Steel Band Conveyor and Engineering Co. Ltd.)

the output of the operative and making possible the use of semi-skilled operatives in an industry sorely pressed for labour.

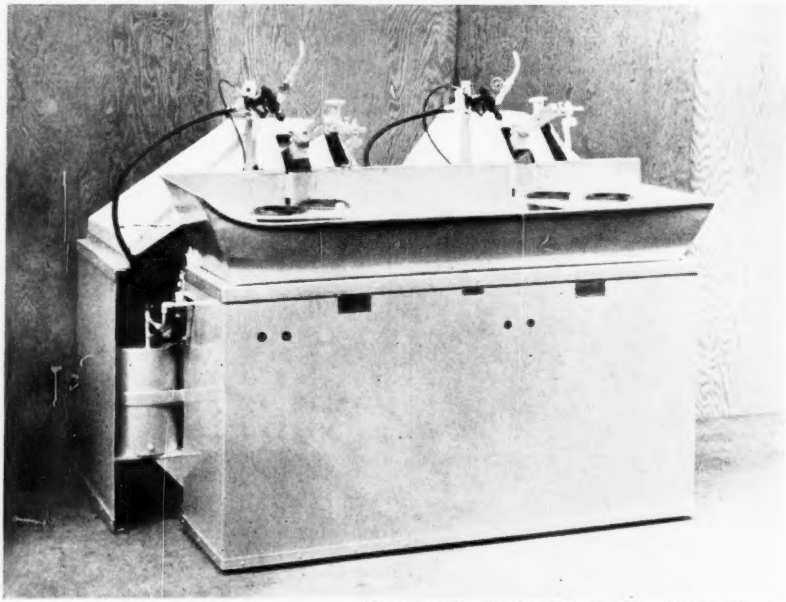
American Machines

Mechanical making methods in America have achieved surprisingly high outputs. In one of these machines the plastic body is extruded from a pug and the slugs of clay are cut off from this and dropped on to the plastic moulds. A heated die then spreads the clay roughly over the mould surface before it passes under the jigger head, where the correct amount of water is sprayed on while the ware is formed under the profile. The moulds then pass under a heated dryer about 100 ft. long heated to 130° F. After passing through this the ware is removed and put on conveyor belts for fettling and sponging and then passes to the team of placers.

The time cycle for the mould varies. On the standard machine it is about 4 hr. from jigger to jigger, but one reads in American literature of other plant where this has been considerably speeded with banks of infra-red lamps. Figures as low as 40 min. have been quoted. For a single line machine an output of 80-110 dozen pieces an hr. can be achieved. Using an eight line machine the production rate is 640 dozen an hr. or 128 a min. In actual practice this figure can be reduced for stoppages from various causes. There are also higher clay losses than are obtained with slower rates of production.

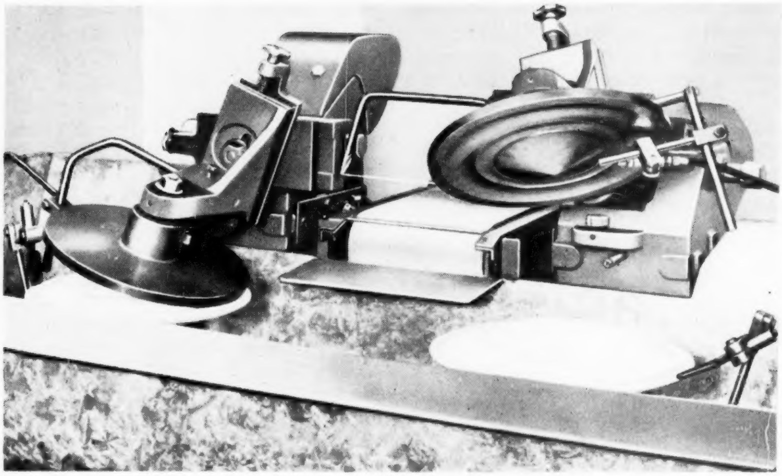
Automatic Cup Machines

With cups a single line machine can turn out 100 dozen an hr. The stripping of ware from moulds can be done either manually or with extra equipment. Such high speed manufacture is only achieved by standardising shapes or by running a single line for each shape.



(Courtesy: Wm. Boulton Ltd., Burslem, Stoke-on-Trent.)

Double automatic cup making machine. One operative with an attendant handles fourteen to sixteen cups per minute



Automatic making machine, developed by Service Engineers Ltd., Stoke-on-Trent.

This lack of flexibility has not appealed to British potters, who have preferred the semi - automatic machine, producing ware at a slower rate, and it is perhaps significant that one American company now markets a semi-automatic system.

American Semi-Automatic Machines

This consists of a batting-out machine making two shapes at once. In this the clay is first pressed to shape by hydraulic pressure between heated dies and then finished by automatic jiggering on another machine with a water spray in the usual way.

It is claimed that an operator can produce at the rate of 24 pieces per min. with this set-up. It has six moulds on a rotating turret head and the operator can load and unload moulds while others are being pressed or jiggered. In operation the machines are simple. The clay bearing mould is rotated and lifted under the heated die or the forming profile as the case may be, with hydraulic pressure. The moulds and dies can easily be changed and pieces up to 12 in. dia. can be made on the machine.

British Semi-Automatic Machines

Our own machines are similarly semi-automatic, and consist of a batting out machine which makes one bat at a time, which the operative has to throw on the clay mould and then put under the profile for finishing—water being sprayed on automatically. The mould is then lifted off to a dryer and another put in its place. A turret head facilitates the changeover of profiles. The operative arranges the operations so that the batting out machine makes a bat of clay while he is finishing the previous article. Such a machine obviates the need for mould runners provided a dryer is placed alongside the machine. Output is of the order of 2,500 pieces per day from each operative.

The cup machine used in this country is rather more like the American semi - automatic. The carrier on the machine holds four moulds, which rotate under the profile which shapes the cup. All the operative has to do is to put the clay

in the mould and feed the latter on and off the machine. The shaping of the cup is done in one operation in one type of machine, and in two in another. In the latter type the cup is first roughly shaped by a profile to run the clay up the sides of the mould. In the second operation the mould rotates under another profile which completes the shaping of the cup—the necessary water being sprayed on as before. An operator of one of these machines can produce cups at the rate of 3,300 per day. In conjunction with a mangle dryer the cups can be transported from the machine to the spongers and handlers, the dry moulds being returned to the maker.

The Roller Machine

A machine of a revolutionary design has also been introduced into this country in post-war years. This rolls the clay on to the mould, the roller taking the place of the usual profile. It is claimed that in this way the clay is not strained as it is sometimes with the ordinary and semi-automatic jiggers. The machine has achieved good results with small-size (up to 5 in.) plates, but the quality is not so good with larger sizes and further work is being done to try to improve this.

Bat Making Not Necessary

A very solid advantage of the roller machine is that it is unnecessary to make a bat and train an operative to throw it on the mould. By means of an automatic feed the wad of clay is brought up to the machine and the required amount cut off. The maker places this on the mould, and leaves the machine to roll it out to shape. Water is sprayed on in the required amount during shaping as in other types of automatic machine. Unskilled labour can thus operate this machine and outputs of the order of 350-400 dozen a day for small flat can be achieved.

Cup turning machine

(Courtesy: F. Malkin & Co. Ltd., Longton, Stoke-on-Trent.)

Cup Handling Machines

Mechanised making does not end when the article leaves the automatic or semi-automatic. Certain types of cups can now be handled by means of a simple machine which takes the cut handles and applies them to the cups so that each registers accurately. To date this is done with straight-sided canteen cups with box handles. More intricate shapes still have to be done by hand. Simple machines for cutting handles in green clay to shape are used in many factories.

Cup Turning Machine

Many articles such as china cups are turned to produce shapes that would be difficult to produce by the more orthodox making methods. This applies particularly to heavy rims on the feet of cups, etc. Turning by hand is rightly regarded as a highly skilled trade and good turners are scarce. A recent introduction in one factory in the Potteries is a machine which automatically turns cups, etc. The cup is held vertically in a vacuum chuck, and by means of a series of cams the profile is turned by two tools which shape the sides and bottom of the cup respectively.

Such a machine can be operated by one woman and an output of 160 dozen china cups each day has been achieved. Such a machine obviously lends itself to the production of large quantities of ware of standard shape. Where many shapes are run the number of profiles required is increased, and tools require changing at more frequent intervals.

Tungsten Carbide Tipped Tools

One of the great advantages conferred in the ceramic industries in recent years has been the introduction of extremely durable substances for those parts of machinery subject

to wear. Thus new alloys are available for pug mill blades and mixers, and recently tungsten carbide has been introduced as a material for tipping profiles and cutting tools used in shaping pottery. Apart from the fact that tool filing is reduced to about one per cent. of that needed with ordinary steel ones, there is the very considerable advantage that greater uniformity of size of ware is obtained, since the tool remains in almost new condition for a longer time, and tool setting is required less frequently. Finality has certainly not yet been achieved in the methods of making pottery and already one hears of dust pressing being tried out for this purpose.

Excessive Handling of Goods

The ceramic industries have always been cursed with the necessity of moving the goods about a very large number of times in the course of manufacture. Some of this arises from the large number of processes required before the final product is achieved, but much of it is avoidable. Many of the older factories grew up from cottages as the industry changed from a craft to its present form. This has necessitated a tremendous amount of carrying ware about on boards—a thing which modernisation of works seeks to eliminate.

In a recent lecture in Stoke-on-Trent it was stated that of all the handling operations in a typical pottery producing tea ware there were only 19·2 per cent. which contributed to the construction of the ware. The rest were transport 49·5 per cent., storage 15·1 per cent., inspection 9·1 per cent., drying, etc., 7·1 per cent. Anything therefore which cuts out unnecessary transport of ware is a direct aid to increased productivity.

Where the works lay-out permits it, conveyor belts, and chain and other types of conveyors are an obvious advantage. For heavier weights such as moving bricks around, fork lift trucks with a brick fork can replace many labourers. On one American brick plant a man with an overhead crane and a brick fork can handle 100,000 bricks a day, while in this country 60,000 bricks can be set in a kiln in 3 hr. with fork lift trucks. Cutting out heavy lifting also makes labour recruitment easier, since it may be possible to use juvenile and female labour.

Increased Rates of Drying Must be Provided

Increased production rates of claywares demands increased drying capacity if a bottleneck is not to hold up production. This fact has not always been appreciated in the past and has led to frantic installation of extra dryers.

Drying of heavy claywares must needs be a relatively slow business for many types of clay, but with lighter articles such as pottery it has been possible to construct dryers such as the mangle and the dobbin which deal with a surprising amount of ware. These machines can handle the output of semi-automatic machines making over 3,000 pieces per day. They can be heated by steam, gas or electricity and can be placed alongside the maker. The towers and spongers can be placed at the discharge end of the dryer which thus acts as a carrier. Thermostatic temperature controls prevent overheating of moulds and ware. The need for a mould runner is eliminated in many cases, and the disappearance of the old heated stillages usually adds space and light to the workshop and improves its atmosphere.

Tunnel Kiln Speeds Production

Sufficient could be written on the tunnel oven as a mechanical aid to production to warrant a complete article in itself. It will suffice to remind the reader, however, of the fact that the kiln can act as a conveyor for ware, reduces the time

required for firing and the labour force required and thus raises production.

Machines for Putting Glaze on Ware

Glaze dipping is still widely used for most kinds of pottery ware, and spraying has hitherto been mainly used for heavy articles such as sanitary ware, and certain types of electrical insulators. Smaller electrical insulators have for long been dipped by threading or hanging on various devices, such as wheels, to facilitate immersion in quantity in the glaze.

Recently an American machine has been introduced into one factory in this country to mechanise the spraying of glaze on flat ware, tea saucers and similar ware can be sprayed at the rate of 300 doz. an hour.

The articles are placed horizontally on rotating holders, which travel in a wide circle. The ware is first slightly heated to assist glaze pick-up, and is then passed under the spraying hood. It is then dried in a short gas-heated tunnel, and passes on to the off-loading point. Excess glaze spray is recovered in a washing plant.

Banks of infra-red lamps and rotating turntables are in use in many factories to speed the drying of ware dipped in the more conventional dipping tub.

Mechanical Aids for Decoration

After glost firing we come to decoration. The bottleneck in producing decorated ware is shortage of labour for decoration. It is not surprising therefore that mechanical aids are being called in to make up the deficiency.

Thus we have power operated presses with heated rollers, on which the pattern is engraved, turning out printed transfer paper for under- or on-glaze printing as fast as the operatives can fix it to the ware. This is still done by hand, and is an arduous and not very interesting occupation.

Machines for accomplishing this

Print rubbing machine for cups

(Courtesy, Wm. Boulton Ltd., Burslem.)

are now in use, including the pressure box, where the paper is fastened to the ware by application of compressed air, the hand press using sorbo rubber pads, and the latest type in which the air under the paper is sucked out and the transfer then fixed by air pressure. Such machines can deal with 12-13 pieces per min. and outputs of 1,500 dozens per week have been obtained (for further details see CERAMICS, June, 1950, pp. 174-180, "Mechanical Aids to Decorating Ceramic Ware").

Gold lining and stamping are now possible with a machine in which the gold is applied to the ware with inked rollers, which rotate while the article is turned under them. Such a single station machine, will deal with 40 dozen of ware per hr., while it is now possible to get a similar machine with six such heads dealing with 200 dozen large plates an hr., using one operator and one helper. The stamping machine can be used for gold and for colours, and gives an output of about 175 dozen an hr. with a similar labour force to the lining machine. The ware carrier can be dispensed with if an automatic take-off for ware is fitted. There are three stamping heads in each machine and, if necessary, each head can stamp a different shape

In this brief review we have outlined some of the more important

(Courtesy: F. Malkin & Co. Ltd., Stoke-on-Trent.)

Ryckman gold-edge line and stippling machine

mechanical aids to production as used in the industry. The question of quality is always hotly debated when the subject of mechanisation is introduced, some holding that a particular machine lowers it, while others insist that it makes no difference. This divergence of views presumably arises from an adaptation of the popular phrase "It all depends what you mean by quality."

ROYAL SOCIETY BURSARY

MR. ROBERT BRIAN JEFFERSON, of 1 Park Avenue, Shelton, a 21-years-old student at Burslem School of Art, has won a Royal Society of Arts bursary of £150 for his domestic pottery designs, submitted in the Society's Industrial Art competition for 1950.

In a report on the competition the Society state that the jury of selectors—Sir Edward Crowe, K.C.M.G., Mr. Keith Murray, F.R.I.B.A., Mr. A. E. Gray and Mr. Harry Trethowan—looked for "freshness and originality rather than for safe-selling commercial designs." The report adds:

Mr. Jefferson was clearly a very competent young designer, who the jury felt would benefit greatly from travel abroad. His shapes were all practical, and both his finished work and his rough sketches showed that he had carefully considered the meaning of every line in his drawing."

F. G. PENNY

INTERNATIONAL COMBUSTION (Holdings) LTD., announce that Mr. F. G. Penny, M.Inst.C.E., M.I.Mech.E., has been appointed managing director of the company, and also of its subsidiary International Combustion Ltd., in place of Sir George Usher who has resigned that position with both companies, but remains a director of each company.

DRYING IN THE POTTERY INDUSTRY*

by

S. R. HIND, B.Sc., A.R.C.S., F.R.I.C.

Part I

IN order to present a picture of drying in the ceramic industry it is convenient to review the subject from a number of different aspects; the *economic*, the *scientific* and the *ceramic-engineering* aspects have been selected for the present purpose. Through each of these, however, run the various processes and scales of production of the very many branches of the industry. The picture is therefore necessarily a complex one and the methods employed are diverse to a high degree and of widely differing efficiency from every point of view.

Water Content

An outstanding feature of ceramic production is that the raw material is brought to a suitable condition for shaping into the desired form by regulating its water content. The way in which the water behaves in contact with the clay and other mineral particles present in the mass is also subject to modification by electrolytes and other agents. The primary control by water content is broadly operative whether we refer to dust-pressing for electrical components, plastic work such as throwing, jolleying, jiggering, pressing and extruding of such articles as pottery and stoneware, or slip-casting for sanitary ware, in which case a highly concentrated suspension is poured into a plaster mould and left to solidify to a stiff plastic mass of the desired shape. All the water added in this way, and much more also in the auxiliary processes of body-mixing, mould making and glazing, must be removed by some means. As far as possible, filter pressing is employed. In the normal preparation of ceramic bodies this reduces the moisture content to about 30 per cent. of dry weight, depending on the body, time and pressure employed. At this condition the material is of a suitable moisture content for plastic processes but of a poor texture and lacking in uniformity. It is therefore subjected to one of the following three processes:

(i) Dried and ground, with adjustment of moisture content, for dust-pressing processes.

(ii) Pugged, preferably in a vacuum double-pug, for normal pressing, extrusion, or throwing on the potters' wheel, where a soft mass, just capable of retaining its formed shape, is required. A resistance to deformation of a few lb. per sq. in. is normal. Apart from throwing for electrical porcelain, in which subsequent drying to a stiffer condition is followed by turning on a lathe, most of the present day throwing (i.e. forming by pressure on the rotating plastic clay) is done by highly specialised machines known as jiggers and jolleys, employing plaster moulds to define either the upper face of substantially flat articles such as plates, or the outside face of hollow articles such as cups. In both cases the remaining face is formed on the rotating mass by means of

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a profile designed to press the clay out into a smooth sheet against the mould, not to scrape or cut it as in lathe turning. These are mass-production processes requiring the greatest care in the preparation of the material and in the construction of the machines and moulds, but no comparable skill on the part of the operative. A common rate of output in such cases, today, is about 15,000 pieces from one machine in a normal day-working week. The weight of product in such cases varies from 2 to 5 ton per week per machine according to the article being made. As every article requires (a) systematic drying, (b) the greatest care not to injure it whilst in a fragile condition and (c) a minimum of labour and factory space, it is clear that the drying of the ware produced in a modern pottery, at this stage, is a serious problem involving a variety of aspects; fuel efficiency is one of these, but by no means the only one.

(iii) For many pottery purposes, for almost all sanitary ware, and for a great deal of electrical insulator production, the filter pressed body is again rendered liquid by admixture with a relatively small amount of additional water together with deflocculants such as silicate of soda, and sodium carbonate or hydroxide. In this way a suspension, or casting slip, is made which works satisfactorily at a density of 1·75 to 1·85 g./cm^3. After casting with this slip in suitable plaster moulds, which receive the excess water and require systematic redrying to keep them in working order, the article in the mould retains about 20 per cent. of moisture on the dry weight. Usually the article is removed from the mould as soon as it has become stiff enough and is finally dried ready for firing. Various processes of joining together, fettling and sponging have to be carried out when the clay is in a suitable condition either before or after removal from the mould; consequently the drying process is hampered, restricted and generally rendered slower and less efficient than the fuel engineer would desire.

When we couple with the considerations already touched upon, that freshly made claywares will often crack is subjected to temperatures of 80° C. or above and that plaster of paris moulds are seriously damaged by drier temperatures in excess of about 70° C., it is not to be wondered at that low thermal efficiency in drying is rather the rule than otherwise and that there is much room for improvement in this field of endeavour.

Economic Factors

Official statistics for the weights of various classes of ceramic wares exported from this country and principally produced in the Stoke-on-Trent area, are shown for three recent years in Table 1. The total

TABLE 1.

	1947 cwt.	1948 cwt.	1949 cwt.	1950 cwt.
Bone-china pottery	67,024	68,835	68,480	92,007
Earthenware pottery	670,620	806,137	814,519	881,002
Sanitary earthenware	529,429	966,806	955,398	1,035,934
Electrical porcelain	62,289	122,062	109,912	114,983
Wall and floor tiles	332,186	547,130	405,498	483,613
Total exports	1,667,548	2,510,970	2,353,807	2,607,539
Total production (tons approx.)	104,100	157,000	147,100	163,000

tonnage figures are based on an approximate figure of 80 per cent. exports.

The following calculation serves to give a broad idea of the economic aspect of the industry's drying problem:

(1) Annual production of ware, approx. 150,000 tons.

(2) Factory make, allowing 10 per cent. loss at appropriate stage of production and in firing 165,000 tons.

(3) Moisture to be evaporated, at 30 per cent. on dry weight = 49,500 tons.

(4) Drying at 60° C. (1,120 B.Th.U./lb. net heat requirement) and with 10 per cent. thermal efficiency, requires $11{\cdot}3 \times 10^{11}$ B.Th.U.

(5) Equivalent exhaust steam (1,150 B.Th.U./lb.) = $9{\cdot}8 \times 10^{8}$ lb. 437,000 tons.

(6) Cost of above exhaust steam at 5s. per 1,000 lb. £245,000.

Associated with this is a charge of the same order for electricity for fans, etc., and also upkeep and capital charges on a sum of £250,000 to £500,000 for dryers.

Summarising, it therefore seems highly probable that the total cost to the industry of process drying amounts to about half-a-million pounds per annum. This cost hinges almost completely on the thermal efficiency which can, on the average, be realised in practice; consequently it may safely be said that there is, in spite of almost revolutionary improvements in recent years, still great scope for improved fuel economy

TABLE 2

MOISTURE/POROSITY RELATIONS IN A NORMAL EARTHENWARE BODY.

Condition of body-material (sp. gr. of dry body 2·615)	*Density, g./cm.^{3}*	*Moisture content on dry wt., per cent.*	*Volume of water, per cent.*		*Linear shrinkage (drying), per cent.*
			Per unit of total volume	*Per unit of solid volume*	
Casting slip at 36½ oz./pt.	1·825	37·3	49·4	97·5	
Body as freshly cast on mould	2·06	20·1	34·4	52·6	3·5
Condition at which shrinkage ceases (est'd.)	2·22	14·2	24·2	37·1	
Dry body	1·91	0·0	0·0	0·0	
Plastic body, pugged	1·90	30·0	44·0	79·0	5·0
Condition at which shrinkage ceases (est'd.)	2·14	20·3	29·7	53·0	
Dry body	1·71	0·0	0·0	0·0	
Theoretical uniformity packed spheres, water-filled (Dilatancy)					
Open packing, cubical	1·85	34·8	47·6	91·0	
Intermediate packing (1)	1·938	27·5	41·8	72·0	
Close-packed layers rolling on layers	1·98	25·0	39·6	65·4	7·8
Intermediate packing (2)	2·055	20·3	34·6	53·0	
Closest packing (piled shot)	2·20	13·4	26·0	35·0	
Closest packing, dry	1·90	0·0	0·0	0·0	

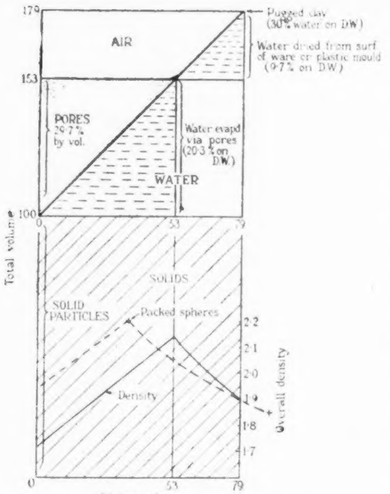

Fig. 1. Plastic earthenware clay drying: volume relations

and reduction of drying costs in the ceramic industry. In fact, it may well be that most of the improved efficiency in recent years is offset, in cost, by the electricity used to accelerate heat exchange and to circulate air amongst the goods, the overriding necessities of recent expansion being mainly (a) to utilise all available exhaust steam and abolish the use of live steam in dryers, (b) to carry out a greater amount of drying in a given shop space and (c) to eliminate the mould-runners who were formerly extensively employed in carrying between the making machines and their dryers. This type of personnel has largely disappeared owing to the unattractive nature of the job.

Shrinkage and Porosity Relations

Figs. 1 and 2 and Table 2 present some of the fundamental data relative to ordinary white earthenware bodies, as normally used for the production of domestic table ware and sanitary ware. Fig. 1 relates to jiggered and jolleyed table ware, with body in which the clay is in its natural, coagulated condition, i.e. the particles group themselves into spongy aggregates which hold a greater proportion of water than occurs in the deflocculated casting slip and the solid body derived from it. This is most strikingly illustrated by the region, in Fig. 2, where the casting slip is liquid at and below the moisture content normal to the pugged body. It can readily be demonstrated in the laboratory that the cast body at 20 per cent. moisture content separates from the casting slip at 37 per cent. moisture with no material of intermediate moisture content or fluidity; that is, regardless of the thickness cast, the run off residue of slip is unchanged in density. This difference between coagulated and deflocculated clay is further reflected in (a) a greater porosity in the dry plastic made article, (b) finer pores in the cast article and consequent greater difficulty in drying, more or less offset by (c) larger amount of pore-water to evaporate from the plastic made body.

At the first sight it would seem that, in drying cast ware, there was the decided advantage of very much less water to evaporate, as the cast article carries only about two-thirds of the water present in the same article jollied or jiggered. Actually,

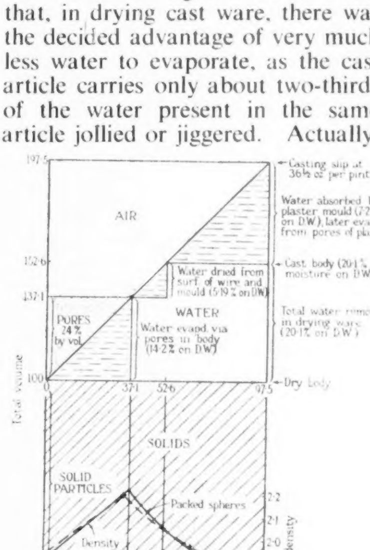

Fig. 2. Slip cast earthenware clay drying: volume relations

the balance of advantage proves to be the other way, seeing that the cast article is, in the first instance, only obtained by first removing a relatively large amount of water into the plaster mould and that, in practice, it is just as necessary to dry the mould as the ware.

"Dilatancy"

The theoretical data at the end of Table 2 concern "dilatancy," or the property of a granular mass by virtue of which its water retention differs according to the state of packing of its particles. This phenomenon is particularly noticeable when one is walking on a sandy sea shore above a retreating tide, and it is not normally observable in plastic clayey masses. In fact, as will be seen from comparison of Figs. 1 and 2 (density curves), the indications are that plastic clay is incapable of packing to the theoretical limit because of its coagulated condition.

With the slip cast ware there is, however, a striking conformity between the simple case of dilatancy and the behaviour of the deflocculated clay. This relationship obviously deserves exhaustive investigation, but the author's tentative explanation of it may be of interest. It is as follows: Casting slip is made with as little water as is consistent with reasonable viscosity (500 to 1,000 times that of water). In the deflocculated condition the solid particles repel one another and are roughly in cubical packing, opened up with a thin layer of extra water between the particles to ensure flow. On contact with the absorbent mould this substantially open packing remains undisturbed except for removal of water to the point where the particles rest solidly one upon another. The freshly cast body is built up of layers all in much the same state.

After completion of casting, the mould still continues to exercise a "pull" on the water between the solid particles of the casting and this can no longer be supplied by slip (liquid) in contact with the cast. Neither can the water in the cast be pulled into the mould without either (a) pulling air into the pore spaces or (b) bringing the solid particles closer together. On cutting away a strip of cast clay at this stage, just superficially dull and free from excess water, and shaking it—gripped at one end between finger and thumb—wet, glossy areas immediately develop on the surface. Obviously, this fits our picture, in that loose packed particles are taking this opportunity to pack closer and release water. Owing to the fine texture of the material (surface factor estimated at about 18 $m.^2/g.$ mean particle size about $1{\cdot}3\mu$) surface tension strongly resists entry of air between the particles and a considerable compressive force develops in response either to suction from the mould or superficial air-drying.

Approaching Theoretical Close Packing

As already mentioned, it is known that, in a deflocculated suspension a large proportion of the particles strongly repel one another by electrostatic forces and therefore tend to assume the loosest possible packing. However, when this tendency is opposed by pressure from surface tension the mass as a whole contracts whilst still completely saturated and eventually attains a state approaching theoretical close packing. That this, in Fig. 2, is so near the theoretical point is partly accidental, as the closest packing possible for the heterogeneous pottery body is, no doubt, somewhat lower than that for a mass of uniform spheres; the particles of the body are not spherical and, moreover, were never completely deflocculated. However, the coincidence may be taken to have a substantial degree of real meaning. From this point onwards, loss of water must take place by retreat of the water surfaces into the body,

with consequent progressive reduction in rate of drying. Ultimately, the last 1 per cent. or so of moisture is even more difficult to remove, being held by molecular forces which reduce its vapour pressure far below that of a free water surface. This stage is not of serious importance in pottery drying as the last 1 to 2 per cent. of moisture can safely be left to be removed during the biscuit firing. It should be noted here that the removal of this last water produces a very marked increase in the strength of the mass.

It will be seen, however, that the greater part of the water to be removed in pottery drying is that which has to diffuse through the pores of the ware or of the mould, and this imposes, at this stage at least, the need for as high a temperature as possible and the disadvantage of a lower evaporative efficiency than applies to the free water surfaces in the first, contractile stage.

Until recent years, when more intensive drying became necessary, it was generally thought advisable to restrict drying of ware on moulds to a maximum of 120° F. as the plaster moulds tended to dehydrate chemically and to lose strength. There is, unfortunately, no precise temperature assignable to this critical point, seeing that the dehydration depends upon a combination of the ambient temperature, humidity and time of exposure. However, of recent years it has been found that, under faster drying conditions, a temperature of about 160° F. (71° C.) is practicable. Under such conditions the life of the moulds is materially improved by applying a saturated warm solution of borax to the underside, where friction on drying shelves and excessive local heat tend to be most troublesome and where the surfaces which register with the rotating jigger head must be as hard as possible.

It is realised that the speed and thermal efficiency of pottery drying

are materially restricted by the necessity of drying a plaster mould along with the ware, and much inquiry is in progress on the possibility of (a) moulding on a more heat-resistant material or (b) transferring the article from the mould on to some heat-resistant support as soon as the contraction stage has been passed. To some extent the latter idea is being applied crudely and often ware is removed from the mould before its time, but general experience has shown that much inferior results are obtained; flat ware tends to be crooked when treated in this way. The main problem in

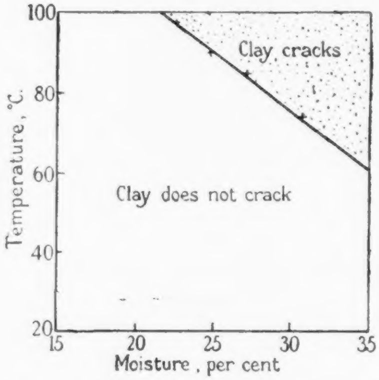

Fig. 3. Cracking in a saturated atmosphere

holloware concerns cups. These, when jollied, are deliberately removed from the mould as soon as contraction permits, as handles must not be stuck on after pores have begun to fill with air. To do so tends to "mort" or irregularly re-expand the clay, which usually gives a crack or a bad joint.

Cracking

The greatest limitation to the rapid drying of clay ware in practice is set by cracking, and a long statement would be necessary to indicate the many circumstances which are known to give rise to it. Badly worn moulds are a prolific cause, especially where they cause the clay to be locked to the plaster where it would normally be released by contraction. For a similar reason the mould may be badly designed for release, or the physical properties of plastic clay or of casting slip may be such as to give inadequate strength or insufficient shrinkage on the mould. Excessive plasticity, on the other hand, leads to excessive sticking and distortion during drying, which would not otherwise occur. However, it is surprising to note the degree to which violently erratic drying, one part of a piece before another, is tolerated by the ware, with certain methods of applying hot air to the drying surface, though this statement is subject to very definite limitations.

High Temperatures

At and above the limit to drying temperature set by the plaster mould there is another limit, set by the plastic clay. Early laboratory work under carefully controlled conditions showed a suspicious frequency of cracking at high temperatures, under humidity controlled rates of drying.[1] This sort of thing was at first put down to some local failure to restrain the rate of drying to safe limits at high temperatures. However, it was shown[2] in experiments in which heating was observed under conditions absolutely precluding evaporation from the clay, that cracking regularly took place at a temperature directly related to the moisture content of the clay. Fig. 3 illustrates these findings, which were curious in that very severe cracks occurred in a saturated atmosphere but the blocks could then be put straight into a hot oven and dried very rapidly. During this drying the blocks not only developed no more cracks but those present usually closed up so completely as to be difficult to rediscover.

The cause for this was sought[3] in loss of mechanical strength on heat-

ing. Fig. 4 demonstrates that the same highly plastic clay as previously used lost two-thirds of its resistance to deformation between 20° and 90° C. It was also proved that air present in the clay, though sometimes the cause of cracking, was not nearly sufficient to account for the phenomenon under examination. Other clays, of lower plasticity, were found to lose strength similarly, but less the less fine-grained the sample. In all cases, of course, the softness of the mass is primarily governed by the proportion of the water it contains.

These findings were later confirmed in Russia.[1] Immediately on cracking in a saturated hot atmosphere, the spherical clay specimen was cut up and analysed for moisture gradients. These were found to be substantial and to be a maximum at the surface, where the temperature was greatest and the crack originated. It was evident that thermodiffusion, or the Soret effect, had taken place to a significant degree and was primarily responsible for the cracking. That is to say, heat applied to the surface of the clay had caused the water present to diffuse inwards at a greater rate than the colder water could diffuse back. Consequently, the pores on the surface contracted and those within expanded, setting up a tension on the surface of the specimen, which, coupled with the reduction of strength of the surface clay on heating, caused rupture. It will readily be seen that such cracks must penetrate to a definable depth but never to the centre; also that increased moisture in the clay reduces the strength and increases the incidence of thermodiffusion, so that the temperature gradient necessary to produce a crack tends to be lower and cracking on rapid heating is more probable. It also follows that the cracked blocks referred to above may be immediately dried with closure (though not reunion) of the cracks in an ordinary hot air oven, as the wet bulb temperature of the heated block would be unlikely to reach the temperature of the hot core until the mass had dried and hardened considerably; so that a reversed thermodiffusion would tend to shut the cracks.

These principles are well worth bearing in mind since they have many practical applications, as, for example:

(1) In humidity drying there is a certain maximum rate of initial heating which must not be exceeded. This will depend not only on the clay in question and its moisture content but also on its shape and any stresses developed in shaping it to the desired form.

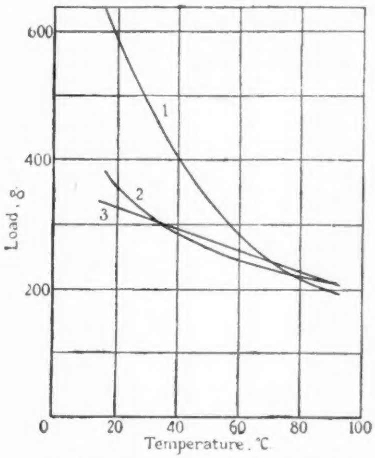

Fig. 4. Loss of strength on heating
1. Standard (34·0 per cent. M.). 2. Leeds No. 13 (23·0 per cent. M.). 3. Scottish No. 4 (22·5 per cent. M.)

(2) Slurried or splashed surfaces on freshly made soft clay articles will readily start cracks, especially minute cracks which can only be found by sponging or spraying the surface with a dye.

(3) Articles of complicated form suddenly put into a hot dryer are liable to soften in certain parts whilst hardening in others, owing to water migration from hotter parts to cooler parts. This may give rise to both cracking and unexpected warping.

(4) Masses of clay ware such as bungs of tiles (e.g. a 6 in. cube made up of 16 or more separate tiles) will be liable to cracking at middles of sides, especially at a distance from the top and bottom of the bung, whilst the same tiles dried separately at a much greater rate will not crack. Generally speaking, care should be taken not to dry thin articles at their edges with humid hot air which has inadequate access to their main surfaces. If, however, this practice is inevitable, the early stages of drying should be with less humid air at a lower temperature and a greater rate of circulation.

Body Composition

Whether the simple concept of thermodiffusion is adequate to account fully for all the phenomena is, nevertheless, open to some doubt. With it must be coupled the peculiar properties of the highly plastic collodial portion of the clay or ceramic body. There is every indication that the more plastic the body the greater the risk of trouble from this cause, whilst it is equally clear that the more fine-grained the texture the smaller will be the pores and the greater the obstacle they will present to diffusion. It appears to be associated with the swelling or *inhibitional* characteristics of clay water systems and the large expansions and contractions to which they can give rise in a soft solid mass. It is therefore wise to restrict the content of highly plastic material in a ceramic body, designed for rapid and thermally efficient drying, to the minimum demanded by adequate strength for safe handling and conveying up to the biscuit firing.

This is well illustrated by the case of two potters' stoves for drying plates, of identical size and type and method of use. One was engaged on drying earthenware whilst the other was dealing with the much less plastic bone china body. In the latter case a much faster drying schedule was possible, with no drying loss, and the thermal efficiency of the stove was correspondingly higher. Thus, an efficiency comparison between different methods of ceramic drying is possible only when the product being dried is strictly the same in all cases. It would, in the present stage of knowledge, appear wiser to concentrate attention on the means of *improving* efficiency, including thermal efficiency, rather than on thermal efficiency tests *per se*. Thus, a general survey of all aspects of one dryer and of its associated equipment, together with the facts regarding its behaviour under a variety of conditions of operation, is immensely more useful in devising more efficient designs and ways of operating than is a collection of thermal efficiency data for units in different factories, though these are valuable as a preliminary.

High Frequency Heating

Before leaving the subject of thermodiffusion in wet clay, brief mention may be made of high frequency electrical heating. In an apparatus capable of 5 kW output at 8 megacycles per sec. it was demonstrated, as expected, that, in the course of drying, the centre of a wet clay mass was hotter than the surface, since the latter was cooled by evaporation. This was favourable to thermodiffusion as an aid to evaporation, so long as contraction of the mass could take place. In these experiments cracking in contact with the supporting surface gave a lot of trouble, so that the expectation that the costly electrical energy would justify itself as an anti-cracking agent at extremely rapid rates of evaporation was not borne out. The bulk of the heat required was to be supplied as hot dry air. The cause of the cracking appeared to be that the rates of heat generation were different in different parts of the same specimen. It has been reported that it is possible with high frequency

current, under suitable conditions, to generated steam safely in the interior of wet clay and so drive out most of the pore water in the liquid form without injury to the shape and continuity of the article being dried. This would, of course, offer prospects of very high efficiency and speed of drying. Unfortunately, the author has not been able to reproduce such conditions experimentally.

Vacuum Drying

In the search for methods of enhancing thermal efficiency in ceramic drying one's thoughts naturally turn to the known fact that water evaporates some thousands of times faster into a vacuum than it does into the atmosphere. Efficient drying usually requires both the removal of water vapour and the supply of the corresponding amounts of latent heat and sensible heat at the greatest combined efficiency. In the drying, as uniformly as possible of pre-formed articles such as pottery, hot air from one source or another proves to be a very convenient means both of supplying the heat and of removing the vapour; in fact, a great deal of such work is carried out under nearly adiabatic conditions. To utilise rapid vacuum drying it becomes necessary to provide a sufficiently versatile source of heat, independent of the means of withdrawing the water vapour. This also should preferably be done under conditions of continuous operation and with articles such as pugged blanks for electrical porcelain, where the intricacy of form is not too hazardous. It would seem better to face the difficulties of continuously or semi-continuously extracting the goods from an evacuated dryer than to have them in masses which could not be uniformly heated from a cheap source of radiant energy. The

ordinary conditions of vacuum distillation, whereby the liquid to be evaporated is in direct contact with a hot surface, are unfortunately not realisable in the ceramic problem and the difficulties encountered are such that very little progress has, as yet, been made in this field.

Stationary Film

Reverting them to drying in a stream of air, which serves the dual function of supplying the necessary heat and removing the resultant water vapour, the problem is basically concerned with the behaviour of the thin film of air so close to the surface being dried that it is either stationary or in smooth non-turbulent motion. Through such a film, heat is transmitted to the ware chiefly by conduction, and vapour escapes by diffusion. These are slow processes and it is therefore advantageous to accelerate them by reducing the thickness of the stationary film. It has been shown[5] that using air velocities up to 1,000 ft./min. the rate of evaporation from a free water surface can be increased by about 200 per cent. This is undoubtedly due to the production of turbulent air flow in closer contact with the drying surface.

Not Fully Explored

The complex behaviour of air turbulence in relation to ceramic drying has not yet been fully explored, as the following example suggests: In a number of large chamber dryers used for drying insulators after turning, it was found that those insulators nearest to the fans dried at a faster rate than those in the air return circuit, where the air had been reheated to approximately the same drying potential. In both circuits conditions of overall air velocity were the same and might have been expected to reduce the stationary films to the same average extent, by the turbulence resulting from the rapid air streams passing over the ware. That this was not the case proved to be due to the additional turbulence created by the tips of the fan blades. When this was largely eliminated by allowing the air from the fans to enter the drying chamber only through slots comparable in area with the free air space between the trays of goods, the rate of drying of goods near the fan was reduced to about half (in the early stages) and became equal to that in the remainder of the dryer. It was thus indicated that one kind of turbulence might be imposed upon another with very material deleterious, or advantageous, effect in drying.

Temperature Raised with Advantage

When, as has been shown to be the case during the major part of ordinary pottery drying, evaporation takes place within the pores of the ware, the effect is that of a great increase in the stationary air film. Consequently the rate of evaporation decreases steadily towards zero as the remaining water is eliminated. At this stage the ware is no longer liable to cracks arising from thermo-diffusion and related causes, and the operating temperature can be raised with advantage. Doing this only partially offsets the lower thermal efficiency arising from the slow diffusion of heat into and of water vapour out of the ware, and it would probably be advantageous to complete drying with temperatures which plaster of paris will not tolerate and, in fact, higher than can be obtained by heat exchange with either exhaust or normal live steam.

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J. D. Sutcliffe.—Mr. J. D. Sutcliffe has been appointed Commercial Director of Richard Sutcliffe Ltd.

ELECTRIC TUNNEL KILNS

By W. L. GERMAN, M.Sc., Ph.D. (Lond.), F.R.I.C.

THE earliest electric kilns used for firing ceramic ware were small decorating kilns firing to 650°-700° C. There are various reasons for this:

(a) the high cost of electricity compared with coal and coal gas as a fuel;

(b) the fact that resistors to stand high temperatures had not reached their present pitch of excellence. Indeed it is true to say that the use of electricity for high temperature kiln heating has followed the efforts of the metallurgist and others to produce alloys, and lately non-metallic substances, which have extended the useful life of resistors at temperatures used in the ceramic industries.

The first decorator kiln in this district was, I believe, erected in 1927 at Josiah Wedgwood's at Etruria and it was a Moore-Campbell straight track type.

Choice of Fuel

The choice of a fuel for firing ovens for ceramic ware is not as easy as appears at first sight. The only rational way of comparing fuel costs is to reduce the price of each fuel to that of a therm, which is 100,000 B.Th.U., and this in turn involves some knowledge of the calorific value of the fuel (B.Th.U./lb. or c. ft.). The subsequent calculation is then a matter of simple arithmetic, and involves finding the price of sufficient fuel to give 100,000 B.Th.U. Thus for town gas and other gaseous fuels it reduces to

$$\text{Price/therm} = \frac{100{,}000 \times \text{price per c. ft.}}{\text{Cal. value (B.Th.U./c. ft.}}$$

while for electricity, since 3,412 B.Th.U. is equivalent to 1 unit then

$$\text{Price/therm} = \frac{100{,}000 \times \text{price/unit}}{3{,}412} = 29{\cdot}3 \times \text{price/unit.}$$

In this way the relative costs of fuels (Dec. 1950) worked out as follows:

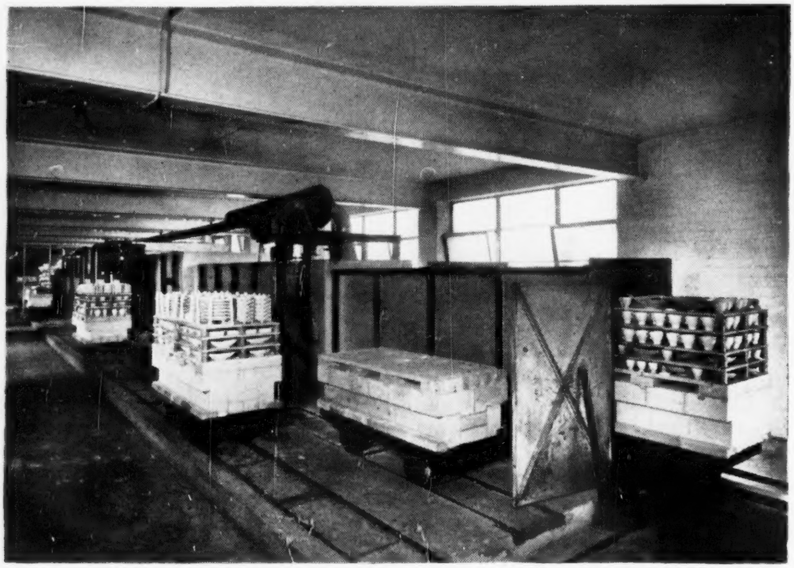
Fuel	*C.V. (B.Th.U.)*	*Price*	*Price/therm (pence)*
Coal	13,500/lb.	60s. ton	2·38
Fuel oil	18,900/lb.	8¾d. gallon	4·97
Town gas	475/c. ft.	3s. 8d. 1,000 c. ft.	9·38
Town gas	475/c. ft.	2s. 1$\frac{5}{16}$d. 1,000 c. ft.	5·33
Electricity	3,412 B.Th.U./k.w.m.	0·6d. unit	17·58*
Electricity	3,412 B.Th.U./k.w.m.	0·72d. unit	21·10*
Electricity	3,412 B.Th.U./k.w.m.	0·72d. unit	21·10†
Electricity	3,412 B.Th.U./k.w.m.	0·84d. unit	24·61†
Producer gas	140/c. ft.	Coke @ 85s. ton	4·34

* Tariff for biscuit and glost kilns Stoke-on-Trent.
† Tariff for decorating kilns Stoke-on-Trent.

The prices are now increased by the latest rise in prices of coal, 4s. ton, coke 6s. ton and a new tariff for biscuit and glost kilns, is now under discussion in this district.

At first sight therefore, it would appear to be a hopeless proposition to fire all but very highly priced ware in electric kilns as far as this

Lecture given to the Electrical Power Engineers' Association at Stoke-on-Trent, on 7th March, 1951.



(Gibbons Bros. Ltd., Dudley, Worcs)

An electrically-fired continuous tunnel kiln for glost earthenware and fancies. The unit is 85 ft. long and was commissioned in 1945

country is concerned. In those countries where coal is not found, and where the import price from this country is about £7 per ton, cheap water power may render electricity the only method of firing worth considering. This holds in Norway, Sweden and Switzerland, for example.

Compensating Factors

There are however, certain compensating factors which offset the apparently disadvantageous price of electrical energy as a fuel. First of all there is the perfectly clean and neutral atmosphere in the kiln, due to absence of products of combustion. This results in two immediate advantages—the ware quality is first class, and saggars can often be dispensed with. The aspect of quality was early recognised in the decorating kilns which were erected in this district now some 25 years ago. The improved appearance of the coloured decorations and the low percentage loss figures soon established the popularity of the electric decorator kiln, in spite of the comparatively high cost of firing over the intermittent coal-fired muffle oven.

The dispensing with saggars allows a much greater setting space for ware in the oven. One authority has stated that the cost of firing ware in an electric oven investigated in this country was double that of a gas-fired kiln with ware in saggars. On the other hand it is possible to set twice as much ware in the electric kiln. Thus the cost is no greater. This statement should I feel be taken with some reserve, because much depends on the design of the kiln. It is possible to get some electric kilns where the cost of firing is undoubtedly heavier than with any other fuel, but there are others, as I shall show later, which are extraordinarily efficient, and in which even in this country the cost of firing is below that of kilns of

similar output fired by other fuels.

Heat Recuperation

There is no doubt in my opinion that in the future, with the rising price of fuels, we shall see more attention paid to heat recuperation in kilns. We sometimes lose sight of the fact that could we completely insulate a kiln and utilise waste heat, the only heat input necessary to the kiln would be that required to carry out the necessary chemical and physical reactions taking place in biscuit and glost firing, etc. With some types of electric kiln the emphasis in the past appears to have been on producing goods of quality rather than considering in addition the fuel consumption. In future designs this will undoubtedly be given more attention.

A further advantage of electricity for heating kilns at the moment is that, unlike gas, it is usually possible to get a supply. Other advantages merit mention. Briefly they are:

1. The ease with which electric kilns can be made fully automatic as regards heating.
2. The absence of ashes and solid fuel which need cartage, and make it difficult to ensure absolute cleanliness.
3. Absence of gas producers, fuel oil storage and pumping, etc.
4. Comparatively low repair costs on kilns.
5. Reduction in labour force required.
6. Better working conditions.

It is not claimed of course that these advantages are peculiar to the use of electricity, obviously they are not. Nevertheless they merit consideration in the choice of fuel. An obvious disadvantage is the high cost of building tunnel kilns at the present time.

Life of Resistors

Having considered the pros and cons of the choice of a fuel, let us now consider the actual heating. As

An electrically-fired Bisq. continuous kiln for earthenware and fancies. This electric tunnel kiln is 119 ft. long and was installed in 1948

we have noted the possibilities of heating depend on the life of the resistors. Of ordinary metallic resistors there are two types in common use in the pottery industry:

(a) nickel - chromium alloy — Nichrome is an example;

(b) an alloy of iron, aluminium and cobalt—Kanthal for example.

The former is an alloy of 80 per cent. nickel and 20 per cent. chromium and is commonly employed for temperatures up to about 1,050° C. For higher temperatures alloys such as 37·5 per cent. chromium, 7·5 per cent. aluminium and 55 per cent. iron, or cobalt 2-3 per cent., aluminium 4-6 per cent., chromium 22-25 per cent. and the rest iron are used. These resistors have about three times the life of a nickel chromium resistor for a given temperature or alternatively can be used to temperatures about 250° C. higher. They contain no nickel and are therefore brittle, and need to be well supported, and handled with care. Nowadays it is common to find Nichrome elements in the cooler and Kanthal in the hotter parts of the firing zone. An average life for Nichrome and Kanthal elements is Nichrome 800° C., 5-10 years; 1,050° C., 2-4 years if glaze is leadless; 9-12 months with lead glazes. Kanthal, 1,250° C., 2 years (Hind, *Pottery Ovens, Fuels and Firing*, B.P.R.A. 1937).

Carborundum Rods

To date no metallic resistor has been made which gives a long life at very high temperatures such as those required for the firing of hard paste porcelain and bone china. For these rods of silicon carbide (carborundum) are used. They are obtainable in standard sizes and are suitable for temperatures to 1,400° C. and can be operated at higher temperatures for short periods. Carborundum has a high specific resistance and is mechanically strong. Unfortunately it tends to grow on use in oxidising atmospheres, and this is accompanied by an increase in resistance, necessitating the application of increased voltage. This is provided for by installing voltage regulators, but it complicates the electrical installation and adds to the cost. These resistors have been used in Continental installations and one is now being used to fire china biscuit in Wedgwoods new factory at Barlaston.

Other possibilities which have not yet been adopted as far as I am aware for firing ceramic ware are the use of tungsten or molybdenum wire coated with a thin layer of beryllia or of alumina, and then sealed up in an evacuated refractory sheath. These have a life of approx. 2,500 hr. at 1,600° C. (cf. *Industrial Furnaces, Vol. II*, 2nd edition, W. Trinks, New York, 1944).

Zirconia and Molten Tin

Other developments are (a) the use of zirconia, and (b) the use of molten tin as electrodes.

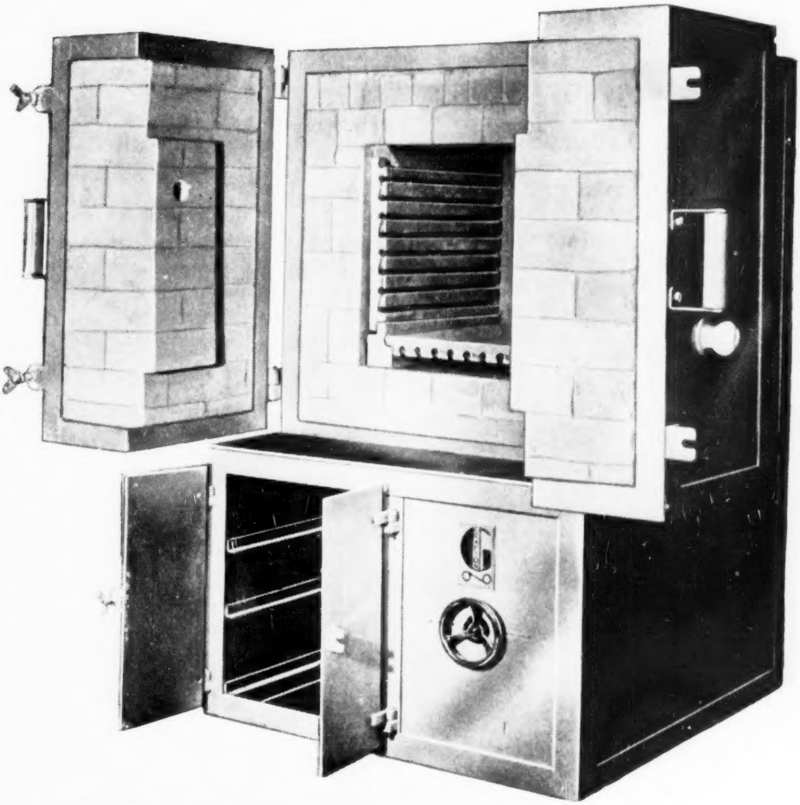
In the first, the furnace chamber is formed by a tube of stabilised zirconia. This is achieved by treating a solid solution of calcium oxide with pure zirconium oxide for 40 hr. in an electric furnace. This results in the following composition:

ZrO_2 (incl. 4·96 per cent. CaO)	99·06
SiO_2 (silica)	0·20
Fe_2O_3 (ferric oxide)	0·52
TiO_2 (titanium oxide)	0·22

When heated at a rate of 10° C. per min. and subjected to a load of 10 lb. per sq. in. collapse takes place at 2,110° C. or with 40 lb. per sq. in. at 1,950° C.

This material has the useful property of a negative resistance characteristic as shown below:

° *C*	*Specific resistivity ohms/Cm.*
700	2,300·0
1,200	77·0
1,300	9·4
1,700	1·6
2,000	0·59
2,200	0·37



Using these properties two types of furnaces have been developed, viz:

A. Ultra-High Frequency Furnace

In this design the insulated stabilised zirconia muffle is surrounded by an induction coil supplied with ultra-high frequencies up to 10 mega cycles.

The muffle is preheated by a gas torch until it becomes a conductor and is then further heated by the surrounding induction coil.

B. Resistance Furnaces

In this type the stabilised zirconia tube is wound with a preheating resistance coil of pure molybdenum, both insulated with zirconia grain. Hydrogen is percolated through the grain as a protective atmosphere.

Electric current is supplied to the molybdenum coil and zirconia tube connected in parallel. Thus when first switched on, the current flows through the molybdenum coil and when the zirconia tube becomes heated and becomes a conductor, the tube takes over and operates as the resistance heater.

Eventually the molybdenum coil only carries about 9 per cent. of the current.

Control is by amperage regulation and not by voltage.

Such furnaces can operate continuously at 2,000° C.

Molten Tin Electrode

This element essentially consists of a quartz tube containing molten tin and has been operating for nearly a year at 1,500° C. without even a millivolt change in pressure drop. Tin has the unusual property of melting around 231° C. (449·4° F.) but not boiling until it reaches 2,300° C. (4,175° F.).

Specific heat at 70° F. = 0·0541; latent heat of fusion = 26 B.Th.U./lb.; electrical resistivity in michrom/cm at 70° F. = 11·5.

The terminal arrangement is simple and cool in that the capillary action of liquid resistance element merely extends into a larger area terminal chamber having lesser watts release for same current. Tungsten electrodes are immersed in these chambers and finally connected to copper conductors.

Mounting of Resistors

Needless to say the resistors should, if possible, be mounted so that they can dissipate heat readily to the surroundings. In this way the possibility of overheating, with adverse effect on life is avoided. The elements are usually in the form of coiled wires for potting ovens, and these are usually fixed horizontally in slots in the refractory lining of the firing zone. This does not facilitate replacement of burnt out resistors, so the usual practice is to fit a number of spares which keep the kiln going until it is stopped annually at wakes week.

An alternative which has been adopted in more recent times is to place the resistors in holes in the sillimanite tiles which form the roof and floor of the kiln. They can be coupled in pairs and replaced by disconnecting from the bus bars and pulling out and replacing without cooling the kiln. Such elements do not appear in the kiln at all and to prevent the danger of overheating in such a confined space, the controlling thermocouples are placed alongside the elements. Other devices which have been used are to put the elements in the base of the kiln car and to wind them on refractory cylinders which are lowered into the sides of the kiln and hung on overhead bus bars. These overcome the difficulty of replacing elements quickly.

Basic Principles of Construction

I now propose giving a few basic principles on the construction of tunnel kilns and will then discuss some of the more interesting examples. Essentially a kiln can be divided into three zones, preheating,

firing and cooling. Since there are no products of combustion to be dealt with the arrangements for heat recuperation on electric kilns are relatively simple. In the Brown-Boveri type they involve introducing cool air into the cooling end of the kiln and piping it over the firing zone into the other end of the tunnel, where it preheats incoming ware. In addition there is provision for heat recuperation by building two kilns side by side separated with a thin wall. These operate on the counter - flow principle and heat transference through the thin party wall results in cold incoming ware being heated by the outgoing ware in the other tunnel.

In one installation in this district one tunnel fires biscuit, and the adjacent one glost, and the cooling biscuit ware preheats the incoming glost ware. In another installation two glost tunnels are built side by side and operate in opposite directions without a dividing wall. In the latest type, which we will refer to as the multipassage kiln, there are a large number of small kilns which can be operated in counter current with very efficient heat recuperation. On far too many electric kilns there is no provision at all for utilising waste heat, and this is reflected in the high electrical energy inputs required.

Types of Kiln

Let us now consider the various types of electric kiln in more detail. We can divide them roughly into:

(a) kilns of the conventional type in which the ware is carried on trucks or on a metal sole;

(b) kilns using wire belts to convey the ware;

(c) kilns using refractory bats for the same purpose, i.e. walking beams and kilns of the Gottignie type.

The earliest types of type (a) were

decorators of the Moore-Campbell type built in 1928-30 in this district. They were straight track kilns roughly 100 ft. in length with a track about 1 ft. 4 in. wide by 4 ft. 6 in. long and the setting height above the car was between 2 ft. and 3 ft. These consumed about 10-13,000 k.w.h. per week (168 hr.) and the weekly output amounted to 3,500-7,000 dozens of ware depending on the firing cycle used. The consumption per dozen of ware worked out at approximately 1·5-2·5 units, depending on the size of the kiln and the cycle. These kilns were operated with two men per shift.

Circular Decorating Kiln

Of late years the circular decorating kiln has become very popular. In this version of the decorating kiln, the ware is carried round on a platform or sole of heat-resisting alloy and the loading and unloading are done at one point. In some ways this is an advantage and in others is not. This kiln can be put down in a space about 30 ft. by 35 ft. which is an attraction on some potteries where space is at a premium. The outside diameter is 27 ft. 6 in. with a mean diameter of 22 ft. approximately. The sole width is 1 ft. 4 in. and the loading height 2 ft. 11 in. An output of 3-4,500 dozens per week is obtainable for a consumption of 2-2·7 units per dozen giving a weekly consumption of 9,650 k.w.h.

A smaller size kiln is available with an outside radius of 22 ft. and a correspondingly smaller output. In construction there is nothing particularly intricate about this kiln. It comprises a straight heating zone on which banks of elements of the coiled wire type are built into the side of the heating zone and are accessible by detachable panels. Heating is controlled by electrically operated thermostats and the kiln is vented to allow volatile oils from the decorating process to escape. Since these kilns are operated at low temperatures the element life is very long (5-10 years) and maintenance costs small.

Biscuit and Glost Car Type Kilns

Of later date are the biscuit and glost kilns of the car type heated electrically. In these again the construction is simple and usually involves banks of resistors built into the side of kiln. The sizes are variable. One biscuit and glost twin is 83 metres long. The maximum designed firing temperature is 1,250° C. and the electrical input 621 k.w. The biscuit tunnel maximum temperature is approximately 1,140° C. and the glost temperature 1,070° C. The biscuit cycle is 60 hr. and the glost 25 hr. The electricity is received at 11,000 volts and transformed down to 415 volts at input of kiln. Such a kiln installation has given 15,000 dozen of biscuit a week and 12,500 dozen of glost. This means that the load on each car is approximately 6 cwt. of biscuit and 2 cwt. of glost. Added to this is approximately twice the weight of kiln furniture in each case. The fuel consumption was 1,135 k.w.h. per ton of ware for biscuit and 800 k.w.h. for glost. This gives a thermal efficiency calculated on B.S.S. 1388 of 42·5 per cent. for ware for biscuit and 32·1 per cent. for glost. For total setting the figures are of course higher and are 70 per cent. and 71 per cent. respectively. For kilns of this size this is a good performance, no doubt due to the degree of heat recuperation given by the use of the counter flow principle.

A similar figure for the intermittent glost kilns (up draught) might be as low as 1·5 per cent.

Metal Belt Kiln

A more recent innovation is the metal belt kiln.* These have achieved some popularity in the post-war years in conjunction with highly fritted glazes maturing in 3-5

* Metalectric Ltd. and Birlec Ltd.—(Ed. note)

hr. The ware is moved on belts of nickel-chromium alloy, and in one type these are 18 in. and 36 in. wide. In this type the overall length is 70 ft. of which the furnace zone is approximately 22 ft. long and is heated by banks of elements on the roof and at the sides. Overall width is 9 ft. on the larger and 7 ft. on smaller models. The working space is about 1 ft. high. The ratings are 180 k.w. and 120 k.w. respectively. The furnace consists simply of a central heating zone. There is no circulation of hot air or any of the devices found on the conventional tunnel oven. Heat creeps down the tunnel, preheats incoming ware and the firing zone is thermostatically controlled in three zones, e.g. 860° C., 1,050° C. and 1,080° C. for a particular glaze. Cooling is effected by passing through two insulated zones and finally through a water jacketed zone. The temperature of this needs careful thermostatic control if cracked ware is to be avoided. The belt is drawn by a motor and the speed is adjustable. Commonly the range provided is 2-12 hr. but this can be extended.

Load and Belt Life

Owing to the small cross section and the relatively high current rating the kiln can be heated up to glost temperature in about 8 hr. and thereafter ware can be put through at a high rate, e.g. mixed tea ware is being glost fired in 3 hr. The through-put is limited by the fact that over-loading the belt shortens its life. Most users put 5 lb. per sq. ft. load on the wire and get a belt life of the order of 9 months. At 7 lb. per sq. ft. the life drops to about 7 months. Most users, in fact, change the belt at 6 months intervals. These belts are an expensive item (prior to devaluation the 36 in. size was in the region of £1,100). Experiments are on hand with the aim of increasing belt life. Shortened firing time of course increases the output and by working these kilns continuously outputs are obtained sufficient to offset the cost of belt renewal and to show savings over intermittent firing.

A typical weekly output of glost earthenware on a 4 hr. firing schedule is:

Saucers	7,500 doz.
Mixed cups and saucers	9,400 doz.
10 in. plates ...	2,500 doz.
8 in. plates ...	6,300 doz.

with a 3 hr. schedule:

Cups	11,000 doz.

These kilns can be fitted into a small space, need little labour, and with the rapid firing rate defects can be spotted and rectified quickly. One manufacturer claims that savings in saggars and labour over the intermittent oven firing pay for two belts a year. This is very satisfactory but there are still many who feel that the high cost of belts is an unsatisfactory feature of this kiln and attempts to improve belt life will be watched with considerable interest.

Walking Beam and Multipassage Kilns

The alternative idea of moving the ware on refractory bats is at the moment attracting some attention locally following the building of kilns of the walking beam and the multipassage or Gottignie type. In the former the ware is placed on carborundum bats which are moved forward by the well-known principle of the walking beam, which has for long been used in metallurgical furnaces. The design is otherwise simple and similar to the metallic belt kilns—the ware is simply carried through a firing zone consisting of banks of electrical elements. In the walking beam type it is possible to achieve a certain amount of bottom heating. The Kanthal elements are completely shrouded in refractory sheaths and replacement is simple. The one in operation at present is 98 ft. long, and the figures given for fuel consumption (glost) are 3·5 units per dozen dinner ware and 2·5 units per dozen of tea ware.

In the foregoing types of small kiln, there is of course no heat recuperation and the inputs of electrical energy are therefore on the high side. In the multipassage type, which is the latest addition to the types of tunnel kiln erected in this district, we have a kiln built in a series of pigeon-holes commonly in units of 16, 24 and 32 small passages. In these the ware is moved on refractory bats through the heating zone, which consists of spirals of resistance wire resting in holes formed in the refractory tiles which form the bottom and ceiling of each passage. The resistors do not appear in the passages themselves. Current from the grid is transformed down to a comparatively low voltage and fed from the bus bars to the resistors. The thermocouples which operate the relay contractors are placed alongside the element coils, and thus prevent overheating them. This is necessary, since there is not that free radiation of heat energy when the element is totally enclosed which takes place when the elements are hung on the kiln walls. The tunnels are of small cross section, thus reducing heat losses, and by moving the ware in adjacent tunnels in counter flow, very satisfactory heat recuperation is obtained as is reflected by the kiln performance. The following are approximately comparative performance figures for earthenware and tile glost.

Type of kiln	*Finishing Temp. °C.*	*k.w.h./ton ware*
Multipassage	1,100	268
Metal belt	1,080	1,200
Twin-tunnel	1,070	800

These kilns have been used now for over 10 years on the Continent for glost and biscuit tiles, floor quarries, biscuit table ware and grinding wheels.

Relative firing costs (December, 1950) are tabulated on the following page.

It is not claimed that the kilns quoted above are necessarily the most efficient, but they represent typical ones taken at random for which data is available.

The electrical input of multipassage kilns is relatively low because of the satisfactory degree of heat recuperation, e.g. a four passage

	Glost (pottery or tiles).				
	Inter up draught	Open flame town gas	Muffle town gas	Electric twin tunnel	Multi-passage electric
Ware	Pottery	Pottery	Pottery	Pottery	Tiles
Placing	Saggars	Saggars	Open	Open	Open
Max. Temp °C.	1,060	1,060	1,080	1,072	1,060
Fuels cost £/ton ware	7·15	5·15	1·7	2·0	1·1

kiln firing 960 dozen per week of mixed tea glost consumed 22 k.w. A larger 24 passage firing 3,600 yd. of tiles per week consumed 80 k.w., while a biscuit oven firing 18 tons per week consumed 55 k.w.

It is quite certain that, as fuel costs rise more attention will have to be given to cutting fuel consumption in electric and other types of kiln and it is certain that we have not reached finality in design by a long way.

Refractories at Work

2.—Atomic Energy

BOTH in generation and in harnessing, particularly for peaceful pursuits, the basic problem is one of handling high temperatures. Already the uses of radio-active tracers both as a tool of the research worker and also for the physician and surgeon are recognised, but in simple language atomic power is really the using of a nuclear reactor to provide thermal energy for power purposes. Compared with orthodox forms of energy, atomic energy means that temperatures in the range of millions of degrees are available if a suitable container can be found. It has been said that nuclear energy must be able to produce heat in the normal temperature ranges commonly employed in industry if it is to be competitive with them. Should steam be the final working material, it must be in the range of from 700°-1,000° F. which in itself means that the nuclear system must be much hotter to allow for the heat transfer temperature differential.

Application

Refractories and ceramics find uses in the production of atomic power in the following way. The reactor and the power plant itself may be built entirely out of metal in which the refractories play an important part in both the melting and heat treatment. The question of metal purity introduces many problems to the refractory crucible maker. When it comes to the ceramic structural and fuel elements for reactors it is quite possible that the best atomic power plant will use metals which are protected by refractory coatings, or metals in combination with ceramics, using materials for which the name "Cermets" has recently been coined. The possibility of a thermo-electric reactor built entirely from ceramic material in which power is fed thermally out of the reactor, or a reactor built of ceramics with metal used in it on the generator and piping for the heat transfer medium are considerations.

Much to Offer

In any case, the ceramic industry has much to offer the atomic energy power development, particularly for high temperature resistant ceramic material. At the present moment the melting point of graphite—about

3,600° F.—is a desirable goal, but in reality there is no limit to the temperatures which might be handled. It is materials with a melting point above 3,630° F. which have the best possibilities for a ceramic reactor. In addition, new equipment and experimental techniques are needed to measure the properties of materials with temperatures above 1,500° C.

In short, atomic energy is another field where the refractory and ceramic technology are of super-importance. Already they have contributed much, but much more remains to be done.

COMMENT—(*continued from page 7*).
the new name for the immediate post-war utility suites.

Lastly, I nearly forgot another show called "Industrial Design and Publicity."

How Britain ever became the "workshop of the world" before the Council of Industrial Design came into being I know not!

"Reading Ability"

From time to time the question of industry and education has cropped up in this column. Recently the Ministry of Education report entitled *Reading Ability*, available from H.M. Stationery Office, price 1s. 6d. has been issued. The appalling figures emerge that 30 per cent. of 15-year-olds, 23 per cent. of 11-year-olds and 16 per cent. of adults fall into the backward or lower groups instead of the expected 10 per cent. before the war. In a world where competition for survival is becoming increasingly difficult, it looks as though there is round about a fifth of the population who are not mentally equipped to earn sufficient to keep themselves, let alone their families. Even in the secondary Grammar schools round about 1 per cent. were in the backward category whereas the secondary modern school houses 50 per cent. of children categorised as backward. Add to this that the secondary grammar schools are creaming the best children for an academic education to fit them for white-collar jobs, and it means that industrial production is recruiting the left-overs!

What a prospect! The present Government set out to avoid exploitation of labour and it looks as though they are fast moving towards that grossly immoral state of society whereby the whip is being welded even more ferociously by those with superior intelligence against those unfortunates who are lacking in this commodity.

Social reformers cannot ignore these figures! A society which does is even worse than the white man, often condemned by the social reformer, who uses a whip on his coloured Colonial workers.

And just to add a final point on the subject, I read the other day "because schoolmasters scorn jobs which soil the hands, the Grammar school boy is fighting shy of joining the building industry . . . they prefer their pupils to take a pen-pushing job." That was said by Mr. Victor Young, President of the Southern Counties Apprenticeship Scheme at a recent meeting. It applies not only to building but to many other walks of life!

In the end industry pays all the pipers—when is it going to call for its own tunes?

ANTIMONY PRODUCTS—PRICE INCREASE

ASSOCIATED LEAD MANUFACTURERS LTD. announce that the basic prices for antimony and antimony products were increased on Monday last (29th January) as follows: "Timonox" Red Star quality (5 ton price basis), £290; antimony oxide "O" quality (1 ton price basis), £287 10s.; antimony metal, Star "C" (10 cwt. and over price basis), £337 10s.; "Tyne" (10 cwt. and over price basis), £325; crude antimony, £250; black powdered antimony, £265.

A CUP "HANDLING" MACHINE

YET another example of the use of an accurate mechanical appliance in replacing a tedious hand operation is that shown by the "Strasser" cup "handling" machine which is made by Service (Engineers) Ltd., and is here depicted in action.

Designed by the patentee, Mr. H. Strasser, the machine has been subjected to rigid tests under pottery conditions, and it is claimed to give perfect uniformity of "handling," coupled with greatly reduced losses in both clay and biscuit stages of manufacture, when compared with the traditional hand operation.

A main feature of the machine is the motor-driven vertical shaft, to which are attached two sets of four revolving arms: a "fixed" upper set equipped to carry cups by use of chocks; and a lower set with each arm carrying a holder or cradle, lined with a flexible rubber die which is shaped to receive a cup handle. Each lower arm is hinged at a point near the central shaft, and has a rising and falling motion which is actuated by means of an arrangement of cam and levers.

Cradles are open in the case of block handles; but where open handles are to be affixed a special box cradle is used.

Operation

As in the case of manual "handling" both cups and handles must be at a correct moisture content. And with the machine in operation, a sponged cup is slid over the chock at the end of a fixed arm, while a sponged handle is placed in the corresponding cradle—already mentioned as being attached to each hinged arm. Clay slip is then applied to the handle at the point of its attachment to the cup.

On reaching a point half-way in its circuit the hinged arm rises to meet its corresponding fixed arm, and cup and handle are brought together under a pre-determined gentle

The "Strasser" cup handling machine by Service (Engineers) Ltd., shown in operation

pressure This is applied by movement upwards of the hinged arm over a freely revolving wheel which is fitted with a pneumatic tyre. This "handling" pressure may be controlled by the degree of inflation, and is therefore capable of almost infinite variation.

Adjustments

Cup chocks are adjustable for position, and this depends on the size and shape of cup in production. Machine "handling" it may be added, is as practicable with a bell-shaped cup as with the straight-sided type. Handle cradles, too, are adjustable for position; and in the case of block handles the latter are gently gripped by moulded rubber dies already mentioned as lining the metal cradles. Release of a block handle from the die takes place on the application of handle to cup, and such release is assisted by the flexibility of the rubber die.

When affixing open handles, the cradle used for block handles is substituted by a special box cradle which is lined with a flexible rubber die moulded to the exact shape of the handle to be affixed. In operation, with the box cradle in the "open" position, a handle is inserted in the die, when the cradle is closed. Following this, slip is applied to both points of attachment to the cup. Then, with the open handle held firmly in position, cup and handle are brought together for joining, when a striker arm comes into operation, opening the box cradle and releasing the handle which is now firmly attached to the cup.

Unskilled Operators

The affixing of cup handles by hand—or "handling," as it is termed—is a skilled operation. So much so, that on the absence from work of a handler, unhandled ware must usually be kept in condition for "handling" by storing in a suitable humid room or cellar until the absentee resumes his duties. Even under the best conditions this adds considerably to cost because of the difficulty of avoiding loss from drying out. In addition, on the return to work of an absentee, the desired smooth flow of production remains impeded by the necessity first to work off the accumulation of unhandled cups.

By contrast, a "handling" machine operated by three unskilled girls can easily keep pace with the production from two semi-automatic cup-making machines, and efficient operators are produced after only a few minutes instruction. This is without detriment to the quality of the finished ware.

Advantages

When "handling" by machine, while one operator sponges and places cups on the chocks, a second sponges and places handles in position in their respective cradles, applying slip to the exposed faces. The third member of the team removes the perfectly "handled" cups, inspects and sponges when necessary, and delivers to dryer. Such a team can handle 14 to 18 cups per min. with ease—a notably high output from unskilled workers.

Other advantages lie in a 75 per cent. decrease in various forms of loss (there are, for example, no "sprung" handles) and in the fact that on installation of a "handling" machine, problems raised by absenteeism among skilled hand operators no longer exist.

Information regarding the machine may be obtained on request from Service (Engineers) Ltd., Leek New Road, Cobridge, Stoke-on-Trent.

Coal Price Protest. Sir Norman Kipping, director-general of the Federation of British Industries, has protested to Mr. Noel-Baker, Minister of Fuel, on the recent increase in coal prices. In a letter it was asked that the increase, and the manner in which it was imposed, be reconsidered immediately.

British Pottery Managers' and Officials' Association

BRANCH MEETINGS

"NEW Developments v. Traditional Methods in the Pottery Industry" was the title of a paper given recently by **Mr. A. J. Dale,** of Johnson Brothers (Hanley) Ltd., to the Stoke Branch.

Mr. Dale said that generally speaking, many of the methods which we may now regard as traditional were the only ones originally available to the pottery industry, except perhaps for minor individual adjustments.

Limited Choice

These traditional methods appear to have been forced on the industry by the limited choice of raw materials, liable to considerable variation in properties. A good example—only one of many—is seen in the traditional methods of ceramic decoration, where the sizes and oils used in lithography and printing were apparently based on the media used by the paint and varnish industries of a century ago.

These materials were mainly the natural oils—linseed, tung and other vegetable oils, and turpentine—which were processed by boiling or other simple treatment to yield the traditional lithographic sizes, printing oils and painting media.

Considerable Variation

Unfortunately these oils e.g. linseed, can vary considerably in chemical build-up according to the geographical source; and since their important properties, such as viscosity, are very sensitive to the factors of time and temperature during processing, we are led to the conclusion that the traditional media used in decoration can vary considerably in essential properties.

As a consequence, the background of traditional methods of ceramic decoration called for craftsmanship and patient skill, and the human factor was essential in the continual re-adjustment of operational details to suit the wide variation in material properties.

Doomed to Failure

In such circumstances, the replacement of hand and brain by the machine must be doomed to failure. The machine is purely repetitive—it lacks the human touch and other senses—and cannot deal with wide variations in material properties.

However, with the remarkable and rapid development of synthetic oils, resins and solvents and plastics in recent years, the problem of ceramic decoration can be completely changed. These materials are controllable—their fundamental properties are constant, or can be varied at will. Processes previously not suitable to mechanical treatment become amenable to machine performance. *Once the compulsion to use traditional materials ceases, the traditional methods are no longer necessarily the only ones available.*

We thus become alert to the remarkable possibilities of developments in ceramics; extreme conservatism of outlook is no longer the best or safest policy.

New Methods and Traditional Materials

The above review refers only to

the field of ceramic decoration, but the principle is general, and will apply with equal strength to all phases of pottery production, from the sliphouse to the packing house. It does not necessarily follow, however, that the change of method implies a complete break with the use of traditional materials.

Sympathetic Modification

Change of method nevertheless may call for sympathetic modification in the traditional materials.

For example, the change from intermittent firing to tunnel oven methods—biscuit or glost, maybe, with curtailed firing cycle—may demand a modification in body or glaze or both, to maintain quality as regards crazing and peeling resistance, or to reduce loss due to warpage. Furthermore, tunnel ovens with their more precise time and temperature factors can call for a greater degree of constancy in body and glaze compositions.

Modern dryers too with their more rapid drying rates require a greater degree of homogeneity than formerly in the uniformity of moisture distribution in the prepared clay.

The same principle appears at each phase of modern ceramic processing—the more artificial the method, the greater the need for a minimum variation in material quality.

New Materials and Traditional Methods

Many types of raw materials have recently become available in ceramic processing—in the various methods of decoration, the conditioning of slop glazes for dipping and spraying, the hardening of the dry glaze on dipped ware, the deflocculants in casting slip preparation, the making of case moulds, and in other directions.

The initial research on the use of these new materials often requires a cautious and thorough approach. If we are not careful, we may be apt to discard too prematurely the use of these raw materials because they do not fit in immediately with traditional methods of production. In such cases, a minor change in method may give us the required result.

For example, the use of new chemicals to speed up casting rates of thick articles may give rise to increased loss during drying in the plaster moulds, unless the traditional timings of the operations subsequent to the actual casting are modified. Or again, a certain agent may confer a very desirable hardness in a dry glaze film, but cause a deterioration in dipping quality, which may be overcome by an increase in slop weight at dipping, or by the addition of a small percentage of a protecting chemical.

New Materials and New Methods

New materials in ceramic processing frequently demand new methods and conversely, new methods often call for change in materials.

Modern chemistry offers us the new materials, and modern physics, the methods. No one can forsee at this stage of ceramic industrial evolution where the developments will lead us. Photo lithography can lead to a great simplification in the manufacture of lithographs, but a newer method which is being developed in the U.S.A.—called "xerography"—may make obsolete the present methods of lithograph production.

In this newer process, the reproduction of the required pattern is electrical. The visible pattern is converted into an electrical pattern, to which a coloured powder is attracted by electrical forces. Transfer of the powder to paper is achieved by a reverse electrical process.

In this way, lithographs and prints may ultimately be applied to

ware without the use of tacky adhesives which are inevitably a source of trouble.

Summary

1. A change in material may require a modification in method; and changes in methods can often call for a sympathetic variation in material properties, to make the method practical.
2. Changes in method of production e.g. in firing, may result in deterioration in invisible quality such as crazing resistance, of the finished ware; and to recover quality, a material modification may become essential.
3. With change in method of production, certain of our guiding laws in ceramics may require a modification in interpretation.
4. With present day rate of invention and evolution, our technical outlook must be kept fluid rather than static.

Discussion

At the conclusion of his paper, Mr. Dale said:

"Far be it from me to belittle or decry traditional methods, but I think the swing is towards changes, and we want to review what is in front of us and what we have to expect.

"We do not ridicule the traditional when we develop other outlooks, but rather do we admire it. It is only craftsmanship which has made many pottery materials processible under traditional methods.

"The view that I hope I have put forward is that there is nothing wrong with traditional methods, but that they were absolutely unavoidable and were forced on the industry by the only materials available—the traditional ones—but which we later knew were considerably roughish in many respects, and called for considerable ingenuity in their application. The real aim of this paper is

to give you nothing factual, but something stimulating."

Firing Losses

Mr. A. Clough asked if Mr. Dale had any views on the age-old suggestion in the pottery industry that the clay should be fired first and the pots made afterwards.

Mr. Dale: "It is a very nice dream. There is still a certain amount of loss in the pottery industry in spite of the so-called clever methods. Losses, I think, are inevitable, so that the aim should be to bring them within reasonable limits.

"Firing losses are probably the worst of all, but they are only due to a change of dimension and shape factors in firing. Clay is a hard taskmaster. If one could get all materials fired beforehand and then combined together it would certainly open up a very nice vista for the future."

Drying Ceramic Materials

Mr. B. M. Murray said that Mr. Dale had referred to tunnel kiln firing as a method by which these new methods could best be handled. There was often incorporated in kiln design insufficient flexibility to cover the variations in time with the constituents treated. He, personally, thought that a great deal of the troubles in ceramic production existed in the early stages, and he felt that the drying of ceramic products had lost a great deal of its faults with fast firing schedules. Mr. Murray said he would like the speaker to indicate whether he thought the de-airing of clays and the grain size of clays had a considerable effect on fast firing schedules.

Mr. Dale: "De-airing of clays does make out in many cases. If a body is susceptible to the airing, the clays vitrify and at greater rapidity. If the body build-up tends to vitrify with greater rapidity it may call for greater caution than in firing under the greater shrinkage rate. De-airing in some respects can be a menace.

"The original research data on de-airing shows there is a limit to the degree of vacuum. If the degree of vacuum is too high you can actually release air bubbles, and de-airing can also be a menace if the degree of vacuum is not sufficiently great. If the vacuum is not sufficiently great you finish up with more air in the clays than in the typical old-fashioned bodies. De-airing can be an advantage but it has its risks.

"As regards grain size, that can let you down in numerous ways. With a grain size of flint which is too small you can upset all the working properties of the body and change the tendencies of the flint. Similarly with clays, some china clays in particular. They may be alright on paper from chemical analyses, but one can get such changes in china clay that normal shrinkage is lost and the shrinkage of the body is changed.

"I think the tunnel kiln people in general, however, have made a pretty good job of this, considering these kilns are even now only in their infancy. I think these methods of firing, particularly the rapid schedule ones, will make a better job of our bodies and of the milling of our materials."

A vote of thanks to Mr. Dale was proposed by Mr. W. Lunt and seconded by Mr. A. Seddon.

STOKE AND HANLEY BRANCH

THE February Branch Meeting was held in Hanley Town Hall on Monday, 19th February, under the Chairmanship of Mr. E. T. Mayer. A vacancy having occurred in the Executive Committee, **Mr. E. Evans** was elected to fill the position. **Mr. A. Seddon** was elected to serve

as Vice-Chairman of the Branch for the coming year.

Internal business was discussed and it was decided that after the normal business at the next meeting a "Question Box" should be held and members were invited to submit questions on problems covering any aspect of ceramics for open discussion. The meeting was concluded by a most interesting talk given by Mr. S. E. Glover, of G. L. Ashworth and Bros. Ltd., on "The History of Mason's Ironstone China," after which the speaker answered many questions on his subject.

Help and Information

It is felt that all members should take advantage of these Branch meetings and play an active part in the proceedings, and by contributing to discussions benefit both themselves and the industry. Help and information on troublesome problems is freely given by fellow members who have encountered and often overcome similar troubles, and these meetings may well prove to be one of the main channels whereby the general standard of efficiency and quality of ceramic production can be improved.

THE MOND NICKEL CO. LTD.

THE MOND NICKEL CO. LTD. announces that Mr. L. H. Cooper has been appointed chairman and Mr. L. K. Brindley managing director. Mr. G. Archer and Mr. A. Parker Hague continue as directors, and Mr. I. A. Bailey, Dr. L. B. Pfeil and Dr. A. G. Ramsey have also been appointed directors.

W. C. F. HESSENBERG

MR. W. C. F. HESSENBERG, M.A., F.I.M., has been appointed deputy director of the British Iron and Steel Research Association, of which Sir Charles Goodeve, F.R.S. is director.

Mr. Hessenberg has been head of the Association's Mechanical Working Division since March, 1947, and retains this position.

On-Glaze Transfer Booklet

FOR those who are going to see the South Bank Exhibition during the Festival of Britain, the Council of Industrial Design has throughout the past year collected many fine examples of British craftsmanship.

To show these exhibits in sequence and to allow easy identification of supplier and use, a photographic review has been produced under the title "Design Review." Among the items shown is the trade booklet "Matthey On-Glaze Transfers for Pottery," produced by Johnson, Matthey and Co. Ltd., of Hatton Garden.

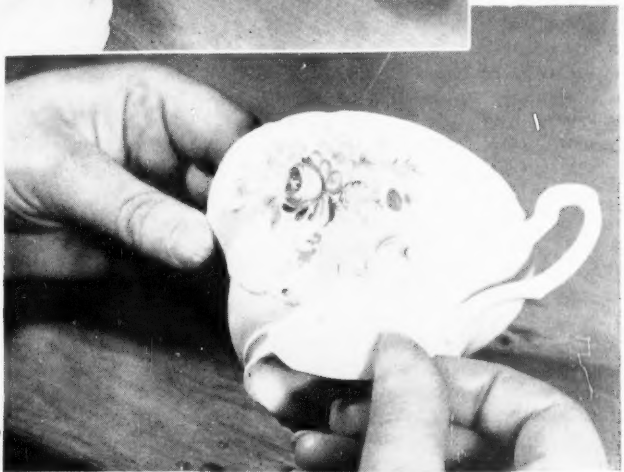
This neat booklet was selected because of its fine design and the quality of its colour illustrations, which emphasise the richness of effect given by the screen-printed transfer process.

Another feature of the booklet that influenced its choice by the Council of Industrial Design is the incorporation of an instruction leaflet for factory use. This is written in the simplest terms and each stage of the transfer application process is shown photographically.

As has been mentioned previously in CERAMICS this new process makes available for the first time many of the advantages of silk-screen printing in the form of an enamel transfer and it bodes to have as much importance to the industry as the introduction of the lithographic transfer process for decorating pottery. The point is that with the new method it is possible for operators of little experience to obtain quality effects previously only attainable by skilled hand painting. This, related to the shortage of decorators in the trade, particularly emphasised by the

Applying transfers to plates as a central spray

For curved surfaces transfers are trimmed close to design with deep cuts made towards the centre of the pattern



Positioning the transfer. Careful work with the scissors has permitted the design to accommodate itself to the shape of the cup

Transfers being used for the decoration of a plate

growth of large Ordnance Factories in the Potteries, makes it a most important contribution.

These transfers by Johnson, Matthey and Co. Ltd. are not replacements for the well-established lithographic transfers, but rather widen the scope of the decorating shop, so helping to increase the production of high quality decorated ware at reduced costs.

Some of the features claimed for them are that after firing there is a richness of the enamel deposit so that the enamels stand out to give a kind of relief effect which is suggestive of hand painting.

Equipment Required

The equipment necessary for their application consists merely of a cloth padded tray, a blotting paper, a rubber squeegee and supplies of clean water. Thus, stripping of the tissue from the back-paper, sizing of the ware, waiting time for the size to become "tacky," hard rubbing down of the transfer, washing off, difficulty in positioning the transfer and delay between application and firing are at once eliminated.

The transfer consists of an enamel deposit printed on to a collodion film, this being attached by a water-soluble gum to a supporting backing paper. The gum also serves to cause the transfer to adhere to the ware, thus obviating sizing. Briefly, the transfer is soaked on a damp pad until the collodion film is detachable. The film is then slid off the backing paper carrying with it sufficient gum to enable it to be positioned on the ware. Water and air bubbles are pressed out with a fine sponge, blotting paper or squeegee.

Range of Designs

Of importance is the range of attractive designs which are available, and in addition the artist staff are always willing to adapt existing patterns to customers' suggestions.

Another important point is that some designs may be sold without discrimination, whereas others may be sold to a customer with exclusive rights on payment of a small charge.

It is pointed out that this process tends not to lend itself wholly continuous border patterns, as the enamel deposit is too thick to permit the film to be stretched, although the effect of a continuous border can be achieved by designing the transfers so that there are a number of very small breaks in the pattern.

The transfers, because of their thick enamel coating, are suitable for incised or "sgraffito" decoration and to stimulate ground laid panels.

Three Groups

The range is divided into three groups:

1. "Easy-fire" resistant enamels for firing at 640°-670° C. (1,185°-1,240° F.) for use on earthenware or china.
2. Enamels firing at 700°-750° C. (1,290°-1,380° F.) according to the nature of the glaze, for use on earthenware and china.
3. Enamels firing at 750°-800° C. (1,380°-1,470° F.) for use on china and felspathic china.

In so far as durability is concerned, all the enamels used by Johnson, Matthey for this purpose are adequately tested for acid, alkali, sulphide and abrasion resistance.

Book of Instructions

The booklet is amply illustrated to show the variety of patterns which may be achieved whilst there is a well-written book of instructions written in a manner which the operative can understand quite easily.

If you would like a copy of this publication for your own reference, Johnson, Matthey and Co. Ltd., of Hatton Garden still have copies available and will supply them on request.

A Review of TECHNICAL CERAMICS

2.—SOME SPECIFIC EXAMPLES

Electrical Porcelains

LOW voltage porcelain, for general insulation, is basically a clay-flint-feldspar or nepheline syenite body, although pyrophyllite, and auxiliary fluxes are sometimes employed. When fired cone Lo-12 (2,300°-2,390° F.), the vitreous product is composed of mullite and undissolved quartz, bonded by a glass phase. Properties of typical low voltage porcelain are given in Table 1.

The dry process of manufacture is most used. In some cases de-airing is resorted to during pressing to give a denser structure and, consequently, a stronger body on firing. De-airing during pressing has found increasing use, whilst de-airing during extruding has long been practised.

High tension porcelain is vitrified, a typical composition being: 30 per cent. kaolin, 20 per cent. ball clay, 30 per cent. feldspar and 20 per cent. silica. In order to insure high dielectric strength the absorption must be less than 0·1 per cent.; this ceramic must be suitable for voltages from 500 to the highest attainable. It must also withstand extremes of climatic conditions. The ware, such as line insulators (pin and suspension types) and strain insulators, is glazed in a single-fire with a high compression glaze.

The normal fabricating methods are plastic-forming, pressing, casting and hot-pressing (use of a heated rotating internal form tool for hollow shapes).

Sparking Plug Insulators

The development of sparking plug insulators from the early classical bodies through the present alumina type bodies coincide with

TABLE 1. PROPERTIES OF SOME TECHNICAL CERAMICS.

Property	*Electrical porcelain* *Low voltage*	*Electrical porcelain* *High voltage*	*Steatite High frequency insulation*	*Zircon porcelain High frequency insulation*	*Cordierite (Porous-type)*
Moisture absorption per cent.	0-1·5	0-0·03	0-0·02	0-0·01	10-15
Specific gravity	2·4	2·4	2·6	3·7	—
Flexural strength, p.s.i. ...	6,000	10,500	20,000	25,000	8,000
Tensile strength, p.s.i. ...	4,000	6,000	10,000	12,700	3,500
Compressive strength ps.i.	35,000	50,000	85,000	90,000	40,000
Impact strength (ft. lb./sq. in.)	0·9	1·5	2·0	2·1	0·9
Mohs hardness	7·0	7·0	7·5	8·0	7
Thermal expansion (linear coeff., by 10⁶, 77°-1,290° F.)	5·2	5·2	8·9	4·5	2·8
Softening temperature, F.	2,550	2,370	2,625	2,930	2,605
Dielectric strength (volts/mil.)	25	250	240	240	100
Dielectric constant (1 mc.)	6·0	6·1	5·9	9·2	5·0
Loss factor (1 mc.) ...	—	0·053	0·010	0·012	·020
Te value, F.	—	535	1,290	1,290	1,435

TABLE 2 CRITICAL-DATA AVERAGES FOR VARIOUS TYPES OF SPARK PLUG BODIES
(According to F. H. Riddle)

Property	Triaxial[1]	Steatite	Sillimanite	Zircon	Spinel	Magnesia	Alumina 80%	Alumina 95%
Specific gravity (gm. gc.)	2.4	2.6	2.5	2.9	3.2	3.3	3.5	3.6
Tensile strength, psi.	6,000	8,500	10,000	12,500	—	—	20,000	25,000
Compressive strength, psi.	55,000	70,000	130,000	140,000		—	205,000	290,000
Modulus of elasticity (psi. x 10^{-6})	12	10	16	21	—	—		
Specific heat (77° to 212° F.) (cal. gm.)	—	—	0.19	0.18	0.20	0.23	35	40
Thermal conductivity (1,600° F.) (cal. cm. sec. C.))	0.003	0.006	0.0048	0.0055	0.0076	0.0107	0.19	0.19
Coefficient of expansion (77° to 1,470° F.) (x 10^{-6})	6.4	8.0	4.6	4.7	9.7	13.9	0.0085	0.0086
Te value (R 1 megohm cm.) (° C)	460	640	650	660	860	1060	8.5 840	8.5 1070
Dielectric constant (2 kc.)	6.5[2]	5.8[2]	6.2	6.8	7.5	10.0	8.4	8.5
Power factor (2 kc.) (%)	0.9[2]	0.17[2]	0.47	0.40	0.10	8.0	0.14	0.07
Loss factor (2 kc.)	5.9[2]	1.0[2]	2.9	2.7	0.75	80.0	1.2	0.6

[1] *Classical porcelain of clay-feldspar-silica*
[2] *1000 kc.*

the progress made in the internal combustion engine and fuels. The characteristics of the insulator, in order of importance, are: (1) good dielectric properties at elevated temperatures, (2) high dielectric strength, (3) good thermal conductivity, (4) good resistance to heat shock., (5) high mechanical strength, (6) resistance to lead compounds, (7) low dielectric constant, (8) resistance to abrasion, (9) resistance to attack by carbon and (10) low modulus of elasticity.

The earliest sparking plug porcelains contained some quartz and feldspar which resulted in relatively poor thermal endurance and electrical leakage at high temperatures. The so-called Marquardt porcelain replaced quartz by a "sillimanite" calcine. In some early sparking plug porcelains, the feldspar was partially replaced by alkaline earth materials, *e.g.*, talc, beryl or calcines.

During World War I, the American Bureau of Standards developed the well-known No. 152 sparking plug porcelain composed of: 20 per cent. $MgO.Al_2O_3.4SiO_2$ (cone 16, 2,642° F. calcine), 40 per cent. $Al_2O_3.SiO_2$ (cone 18, 2,705° F. calcine), 30 per cent. kaolin and 10 per cent. ball clay, thus eliminating both the quartz and feldspar. This body was single-fired at cone 16 (2,642° F.), using a hard porcelain glaze.

Following World War I, most of the bodies used were either of the mullite or zircon type. The so-called "sillimanite" calcine was found to be mullite.

The zircon type of sparking plug body developed during the same period has been classified according to the amount of zircon added: low about 20 per cent; medium, 30 per cent; and high, 55-60 per cent. Quartz and corundum found use in the low zircon body, one of the sillimanite group of minerals in the medium type. The zircon type insulators, having similar physical properties to those of mullite composition did not meet the more severe requirements.

Alumina type bodies found application about 1935 and were used almost exclusively for aircraft engines in World War II. Such a body is almost entirely alumina to which small amounts of flux can be added. Bodies containing more than 80 per cent. alumina (cone 15, 2,750° F.) and as much as 95-97 per cent. alumina (cone 28-32, 2,939°-3,092° F.), have been developed. The use of a highly sintered soda-free alumina instead of the electrically fused dense crystalline product has contributed to this development. The physical characteristics of this type of insulator were greatly superior to those of any previous products, but the alumina type body is abrasive and difficult to fabricate.

Various methods of forming non-plastic bodies, e.g., alumina type, have been developed such as injec-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tion moulding and slip casting in rubber moulds small pellets (spray dried). In the injection moulding of alumina sparking plug bodies a thermo-plastic resin and plasticiser are included with the batch, heated in the cylinder to plasticising temperature, and injected into cold multiple capacity dies. The plasticiser and resin are driven off during the firing. Much improvement has been attained in control of firing.

Numerous compositions have been tried including: magnesia, beryllia, spinel, alumina, chromium and iron oxide, and combinations of these and other earth oxides. Typical physical and chemical data for a number of types of sparking plug bodies are given in Table 2.

The superior performance of the alumina type body has resulted in its present wide acceptance. Besides their principal use as sparking plug insulators these bodies have limited applications in the electronic field.

Steatite Type Bodies

Steatite or steatitic porcelain is produced largely from the talc ($3MgO.4SiO_2.H_2O$). Talc acts as a flux but it shortens the firing range since it decreases the viscosity of the glass phase. Close firing control is required for high talcous bodies. On firing normally to cone 12-13 (2,390°-2,462° F.) the principal crystal phase is clinoenstatite, and cristobalite is present in lesser amounts.

If additions of clay and fluxes are disregarded and the crystal development is complete, steatite would consist approximately of 83 per cent. clinoenstatite and 17 per cent. cristobalite. As a major constituent talc acts as a refractory; the clay and alkaline earth additions act as fluxes to give the glass bond. Both clinoenstatite and cristobalite influence the properties, as do the fluxes used. The alkaline earth fluxes affect the dielectric properties but not as adversely as alkali fluxes (feldspar and nepheline syenite). Steatite is given a rapid firing to produce a maximum of small crystals and as a result a stronger body.

A general formula for this type of ceramic is: 70-90 per cent. talc; 0·10 per cent. kaolin, and 0-10 per cent. barium carbonate.

Steatite compositions, containing little or no plastic material, present problems in fabrication and have a short firing range (68° F.), requiring close control. The raw materials are ground together, organic binders added, and the material granulated. There are three methods of forming in general use: (1) pressing, using automatic or hydraulic presses; (2) extruding from a hydraulic press with, in most cases, subsequent machining; and (3) slip casting in plaster moulds. Because of its non-abrasive characteristics, steatite lends itself to rapid accurate production of small parts on automatic presses.

Steatite is used extensively as insulators for high frequency applications because of its very good mechanical and dielectric properties and low power losses at high frequency. The thermal endurance of steatite is poor, limiting its application in cases where good heat shock is prerequisite.

Tolerance requirements ± 1 per cent. or nothing less than 0·005 in. are the accepted standards for pressed or extruded unglazed steatite parts, but special requirements for certain critical dimensions, which are more exacting, are rather common. These are sometimes obtained by grinding, and sometimes by a 100 per cent. inspection which discards the off tolerance pieces. Close quality control must be maintained throughout all operations to insure a minimum loss in the final inspection.

The average properties of steatite for high frequency insulation are compared with other ceramics in Table 1.

Block talc, made from natural stone and frequently referred to as lava, was formerly used and still is on an experimental basis for insulators, such as tube spacers. It also has been used in the past for refractory parts. While readily machined, considerable material loss is experienced due to faults in the raw material. Commercially, the use of this material is handicapped since the hand machine work involved cannot compete with automatic presses, but the use of block talc is convenient where only a relatively few parts are required.

SYNTHESIS OF QUARTZ CRYSTALS

CONTINUING progress in the applications of radio techniques makes increasing demands on the performance and versatility of the various components used. One such component is the piezo-electric crystal, and research into the synthesis of quartz crystals has shown marked progress during the past year. Crystals have been grown in about 10 days by the temperature gradient method, using crushed crystalline quartz as the starting material. Z-cut quartz "seeds" were used, and sound piezo-electric material has been deposited during the whole growth cycle. The isothermal method of quartz synthesis, using silica glass as the starting material, is still of particular value owing to the speed with which a satisfactory crystal can be obtained. There is now a real prospect that much larger crystals will be grown when new and larger equipment has been put into service.

(From a G.E.C. Report.)

MR. W. E. BAINES

IT is with extreme regret that we heard of the death of Mr. William Edward Baines a member of the firm of C. J. Baines and Co. Ltd., Colour Manufacturers, Sutherland Works, Stoke-on-Trent, recently, at the age of 67. Mr. Baines was a grandson of the founder of the firm and was well known in the North Staffordshire area. During the 1914-18 war Mr. W. E. Baines served as a Lieutenant in the North Staffordshire Regiment and much sympathy will be extended to his family, particularly by his friends in the Pottery Industry.

Lightweight Firebrick Patenting Furnace

PATENTING is a specialised form of heat treatment for obtaining structural characteristics necessary for subsequent cold drawing of such products as rope and spring wires and tyre bead wire. The treatment is continuous, with single strands of the wire or rod pulled through the furnace at various speeds consistent with their size.

Temperatures employed in patenting vary from around 1,650°-1,850° F. depending upon steel composition and ultimate physical properties desired in the finished cold drawn product. Most important, the furnace must maintain uniform temperature throughout the greatest possible length of the heating chamber.

The use of lightweight insulating firebrick in the construction of wire and rod patenting furnaces has proved to be entirely suitable. Through the use of these materials, a great reduction in weight of equipment has been realised. This in turn lowers appreciably the heat storage value required for any one temperature in a given furnace.

The old furnaces were built upon a solid foundation consisting of concrete, red brick, and sand. The arch, walls, and hearth sections representing the hot faces were of ordinary firebrick construction having a thickness of approx. 9 in. Surrounding these sections was a 9 in. thick solid layer of brick of relatively low insulating value. All of this brickwork was encased in the conventional manner by a steel plate shell.

In the construction of the new furnaces, lightweight insulating firebrick was used throughout. In addition, the solid foundation in direct contact with the earth was eliminated. The hot faces of the new furnaces represented by the arch, walls, and hearth are constructed with Babcock and Wilcox K-23 insulating firebrick. This structure has a nominal thickness of 9 in. as shown in Fig. 1. Surrounding the 9 in. layer of K-23 is a 4½ in. thick layer of B. and W. insulating firebrick K-16. In addition, a 3½ in. layer of refractory B. and W. Kaocast, is placed upon the hearth or furnace floor. Instead of a solid foundation, the furnace bottom rests upon a steel floor 18 in. from the ground, thereby providing a so-called ventilated hearth.

Another feature in favour of the use of insulating firebrick in wire and

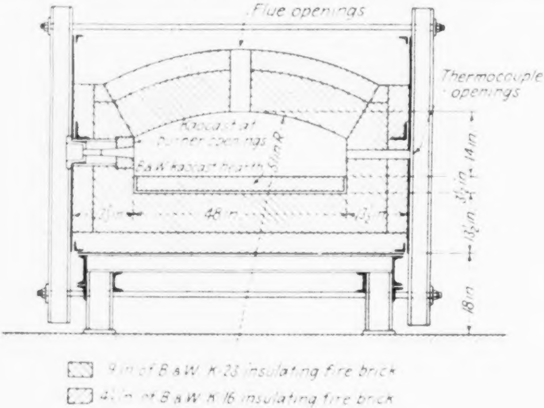
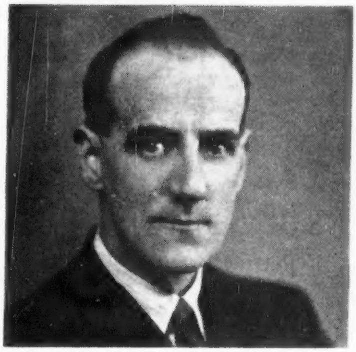


Fig. 1. End section through one of the 50 ft. steel wire or rod patenting furnaces. Use of lightweight B. and W. insulating firebrick is shown

rod patenting furnaces is the relative ease with which the furnace can be brought to operating temperature. It required from 2-4 days to reach the desired temperature and attain temperature uniformity in the old furnaces. In the new furnaces, a temperature of 1,750°-1,800° F. can be reached in from 3½ to 4 hr. starting at about 200° F.

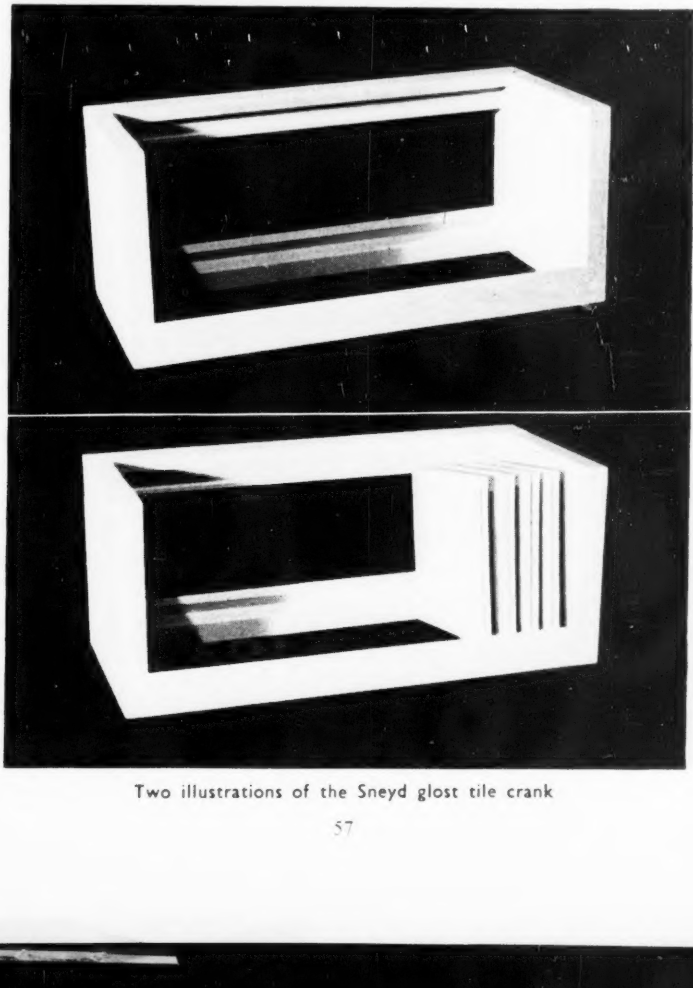
Iron Age, U.S.A. 166, 24, 112-113.

NEW APPOINTMENT— NEW VENTURES



Mr. T. J. Stanistreet

WE have just heard from the Sneyd Brickworks Ltd., Nile Street, Burslem, Stoke-on-Trent, that Mr. T. J. Stanistreet, late of J. Hewett (Fenton) Ltd., has joined their Company, and the future policy will be to extend the manufacture of high grade refractories for industrial and domestic use. The Company is of course an old-established one and among their present interests is the



Two illustrations of the Sneyd glost tile crank

specialising in heavy and lightweight refractories for use in pottery tunnel kilns.

Mr. Stanistreet is a well-known figure in the Potteries both socially and in his contacts as a practical technician, and we wish him well in the future.

Just come to hand are details of the Sneyd Glost Tile Crank shown in the illustrations. Among the features of this crank is a considerable decrease in the weight of refractory used as compared with a saggar. An increased payload, easier loading, a more equal distribution of temperature throughout the crank and a saving in the cost of refractory as compared with the saggar, are very pertinent points indeed.

FIVE YEARS OF CO-OPERATIVE RESEARCH

IN the report of The British Iron and Steel Research Association, issued in January, 1951, under the above title, reference is made to the part played by refractories, as follows:

"Basic" Bricks

In work on refractories B.I.S.R.A. collaborates with the British Ceramic Research Association. The most important recent development is the use of "basic" bricks for open hearth furnace roofs. Their higher melting point allows higher operating temperatures than with the usual silica brick roof. Four all-basic furnaces are in operation in the United Kingdom and detailed observations are being made to see how far greater output and longer life justify a construction cost of about three-and-a-half times the normal.

The importance of economies in the consumption of ingot moulds may be understood from the estimate that the steel industry spends £4,500,000 a year on ingot moulds, after allowing for the sale of scrap moulds. In addition, considerable economies can be obtained if the amount of discard in each ingot can be reduced. The members of the research committees on ingot moulds have supplied a very large amount of works data on mould use and casting practice which the Association has collated. This work has led to changes in the method of use and in the design of moulds which have increased yield and life. For example, an inserted brick type of feeder head has been developed which gives reduced piping and which has a very low maintenance cost. Other investigations have emphasised the bad effect of setting moulds too close together in the casting pit; in one works mould life was increased by about 50 per cent. by simply setting two moulds on each bogey in place of the usual three. The relationship between the composition of the iron of which the mould is made and mould life has also been studied and it is found that moulds up to 4 tons capacity last longer when made of iron combining relatively high phosphorous (about 0·25 per cent.) with low silicon (about 1·0 per cent.).

Large economies could be effected at the soaking pits if a more exact method could be found than those now used for deciding how long the ingots shall remain in the pits. Time studies of the transport of ingots from stripping to the pits and mould and ingot temperature studies are being used in an attempt to reduce fuel consumption per ton of steel passed to the rolling mills. In connection with this work a radiation method of solving the difficult problem of measuring surface temperature of red hot masses of steel has been developed.

STONE AGE TO PRESENT DAY

THE Victoria and Albert Museum, London, have issued Introductory Leaflet No. 3, at a price of 2d. describing an Exhibition of Pottery, Porcelain and Glass, from the Stone Age to the Present Day.

This exhibition has been planned to review in outline the whole history of the arts of the potter and glassmaker from their earliest stages to the present day. Wares of many countries and periods are included, but beauty of form and decoration rather than historical interest has been throughout the ground for inclusion.

The leaflet gives a résumé of the various sections, and if the exhibition cannot be visited, would in itself be a worthwhile purchase.

CARBON AS A MATERIAL OF CONSTRUCTION

RECENTLY a meeting of the Bristol Section and the Chemical Engineering Group of the Society of Chemical Industries was held jointly with the Chemical Society and the Royal Institute of Chemistry in the University Chemical Department, Woodland Road, Bristol.

Mr. J. W. Steventon occupied the chair, and welcomed Mr. Norman Fraser, Chairman of the Chemical Engineering Group, and, as has been the custom for many years, invited him to preside over the meeting. Mr. Fraser then called upon **Mr. A. W. Morrison, B.Sc.,** of the Chemical Carbon Division, Powell Duffryn, to present his paper on **"Carbon as a Material of Construction."**

History

Mr. Morrison first traced the evolution of carbon usage. Natural graphite and clay mixtures were used in the Middle Ages to produce non-ferrous metals and alloys. Next came the development of electrodes during the nineteenth century, and on the techniques developed then and during the first years of the twentieth century the production of constructional carbon was based.

Although carbon blocks had been used as a refractory material for many years, the real appearance of carbon and graphite as a chemical engineering material was in the 1930's when synthetic resins and plastics made non-porous carbon tubes a practical proposition. In the manufacture of carbon shapes two methods are adopted. The first of these involves the use of ground coke, for example petroleum coke mixed with coal tar derivatives or a resin. This is moulded or extruded and the shaped mass heated to temperatures in the region of 1000° C. to carbonise the bonding agent and give a solid carbon. The second method, developed recently in Britain, uses finely ground coal mixed with a swelling inhibitor. The resultant product on heating to high temperatures is a carbon of very uniform texture and a greater mechanical strength than that made by the traditional methods. The carbon produced by either of these methods has a low thermal and electrical conductivity, but artificial electro-graphite with a comparatively high conductivity can be made by heating the carbon shapes to over 2000° C.

The physical properties of carbon and graphite lie midway between ceramics and metals except in one important respect, thermal conductivity. It is not generally realised that graphitised carbon has a thermal conductivity about twice that of iron or steel. Carbon and graphite are much stronger in compression than tension. The chemical resistance of the material is very great as it is completely inert to everything except very strongly oxidising acids at elevated temperatures.

Carbon equipment has design problems of its own but tubes for valves, ejectors, pumps, tiles, tower packings and gland seals are everyday articles which can be made in carbon and graphite.

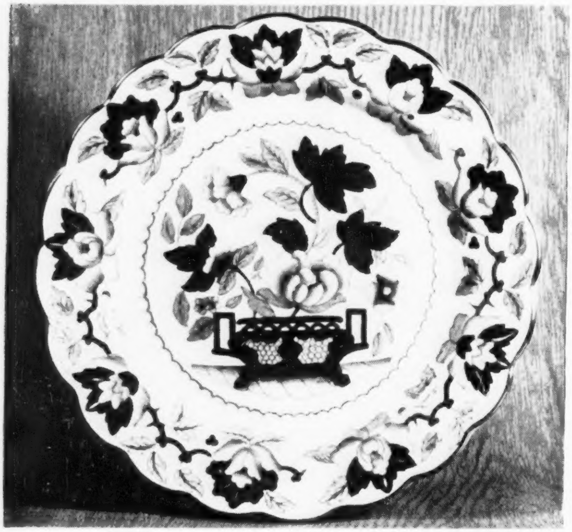
The logical development of graphitised carbon is in heat exchange. Carbon can be used to make cascade coolers, concentric tube and multi-tube and shell exchangers. A very recent British development is that of the carbon cubic heat exchanger whereby a built-up block of electrographite is pierced with holes in two directions at right angles to one another. The resultant very robust equipment avoids the troubles of floating headers and damage to tubes, while giving an exceptionally high overall coefficient of heat transfer.

Of Great Interest

The paper was illustrated by specimens and from the discussion which followed it was evident that the subject had been one of great interest. Mr. Steventon, Chairman of the Bristol Section, S.C.I., proposed a vote of thanks to the lecturer. Following the lecture the usual dinner was held, by courtesy of the University Authorities in the Senior Common Room of the University Refectory.

SOME USES OF VERMICULITE

IN the January, 1951 issue of CERAMICS we published an article by Mr. W. B. Dodgson, A.M.I.B.E., under the above title, in which was shown a photograph of vermiculite, before and after exfoliation. Acknowledgment should have been made for this to the Industrial Laboratory of the North Thames Gas Board, Research Department, Watson House. This was originally used in a paper by Mr. E. A. K. Patrick, entitled New Refractories and Insulating Materials, which was presented to the London and Southern Junior Gas Association on the 1st March, 1950, and published in CERAMICS, April, 1950.



Shown here is "Green Lotus," an old Oriental design which has been produced by Booths Ltd., for a great number of years. It is a printed and enamelled underglaze, and while the original drawings have been maintained the colourings are in the modern style

ADVERTISERS' INDEX

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